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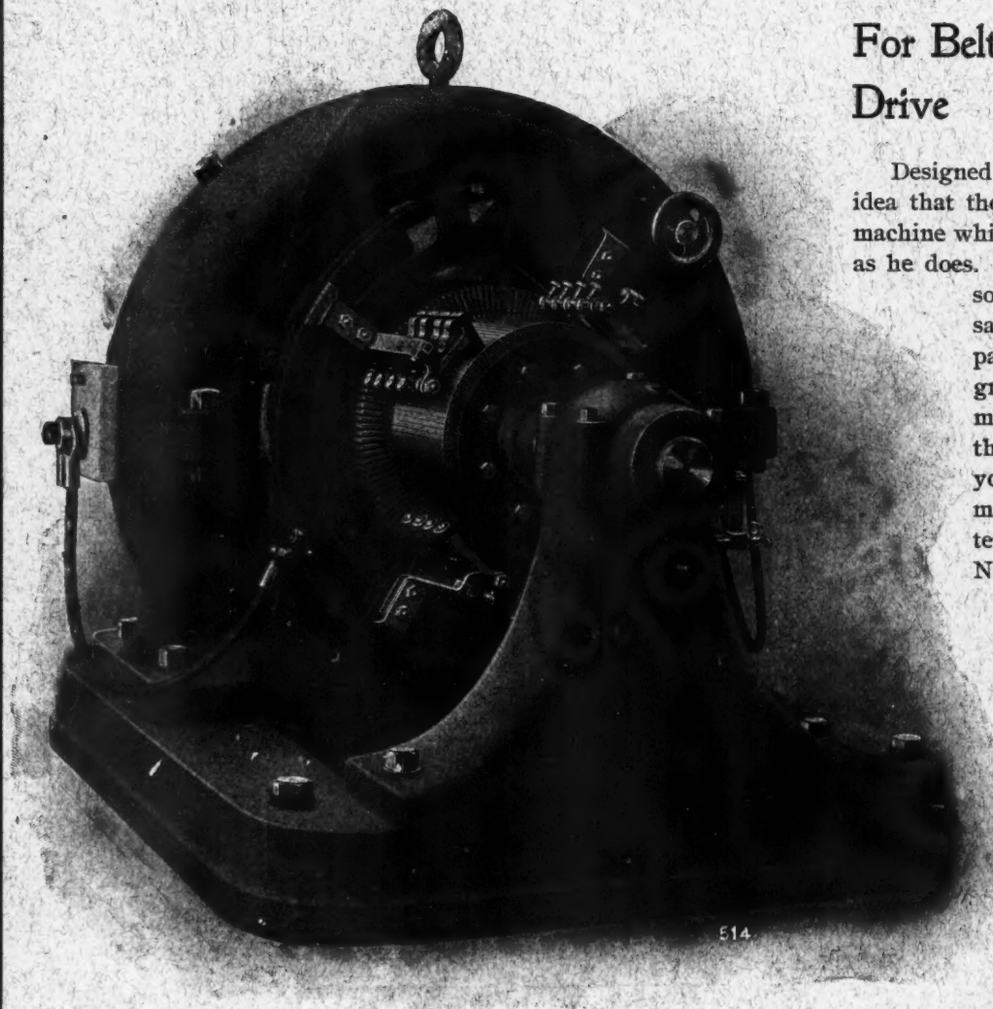

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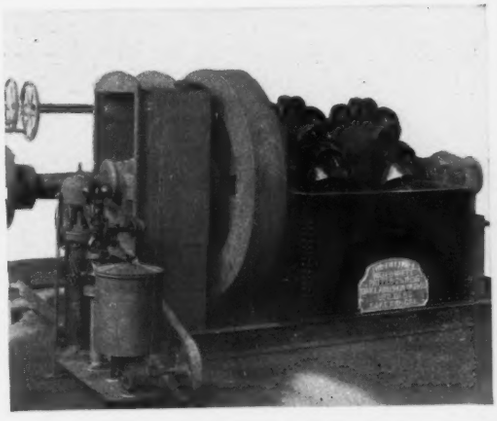

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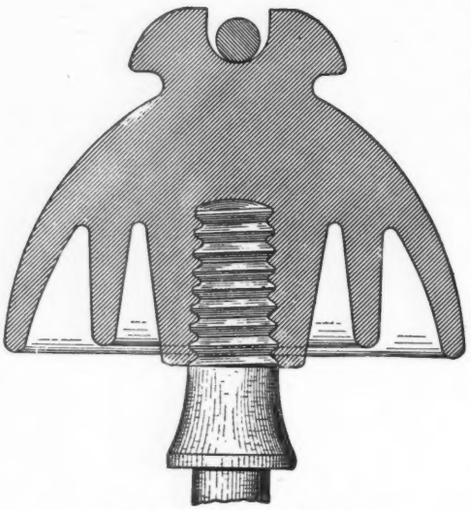

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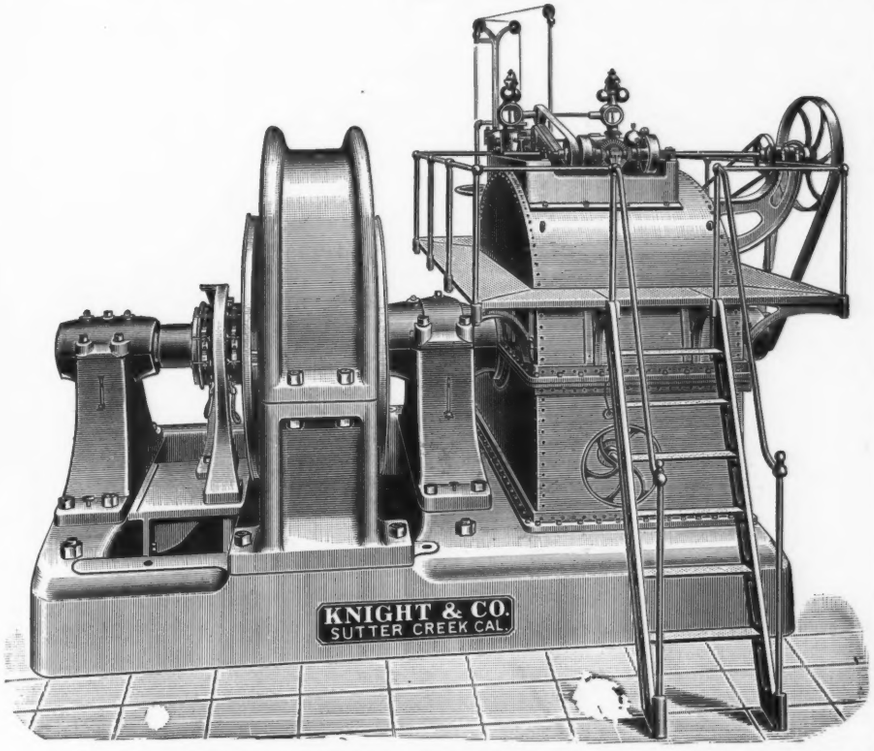

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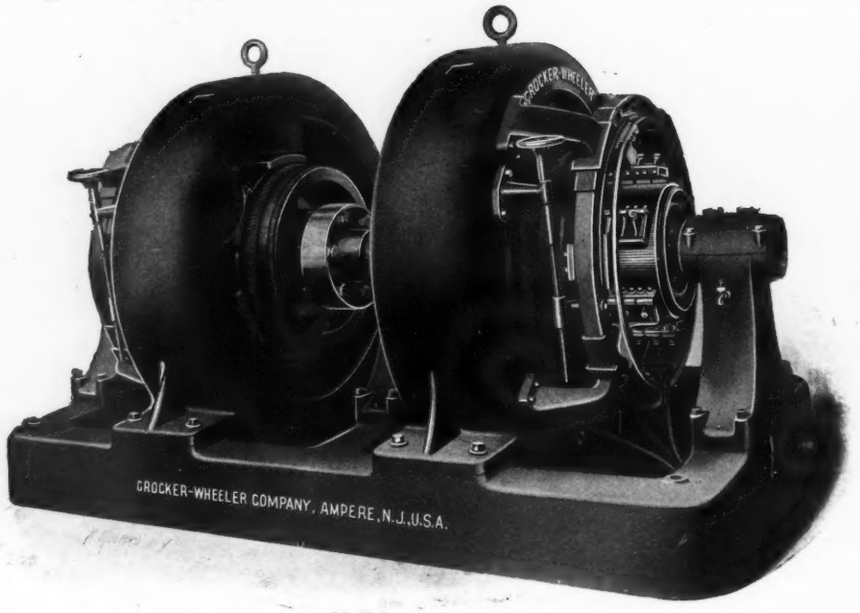

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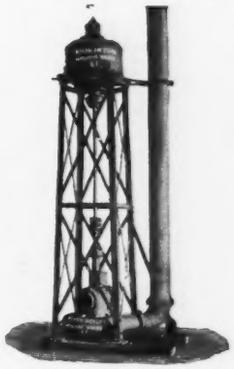

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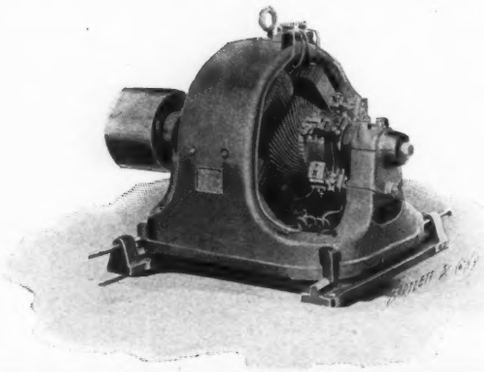

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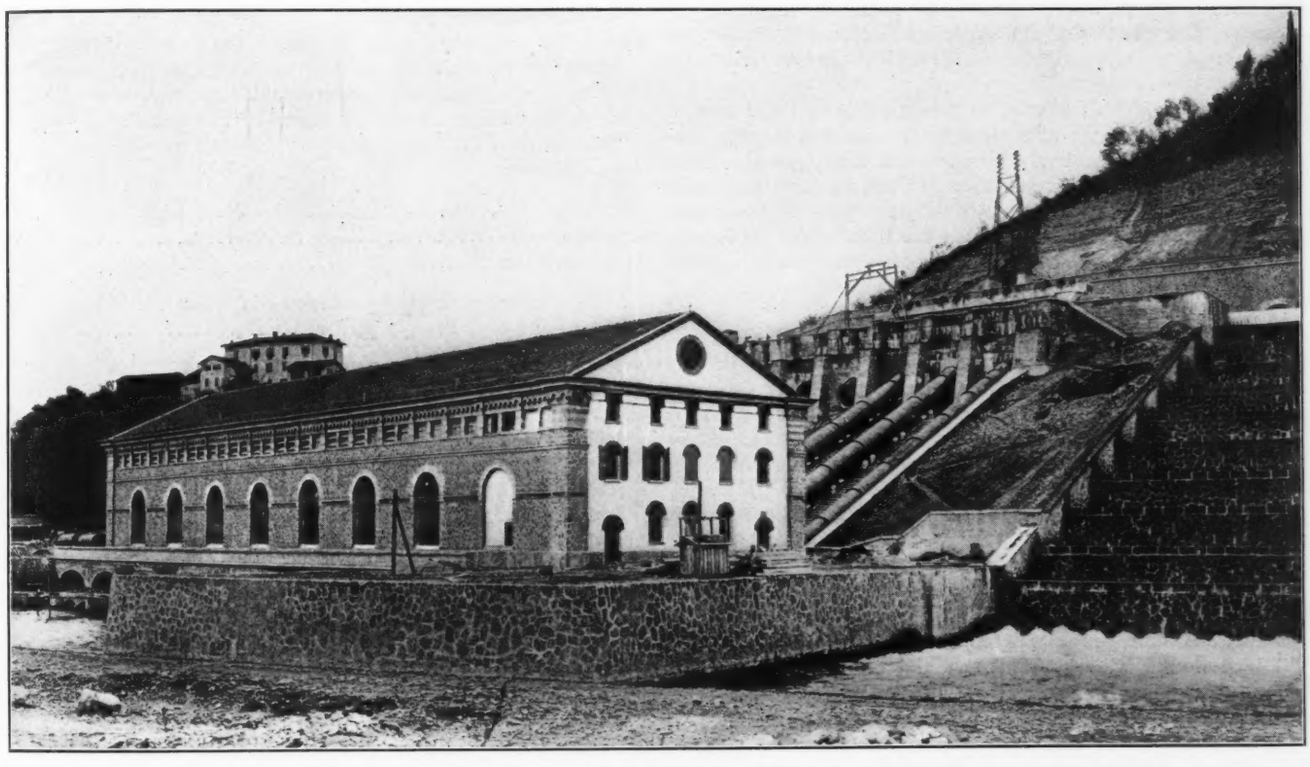
Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XII. SAN FRANCISCO, MARCH, 1902. NUMBER 3

The Paderno-Monza-Milan Transmission.

BY FRANK C. PERKINS.

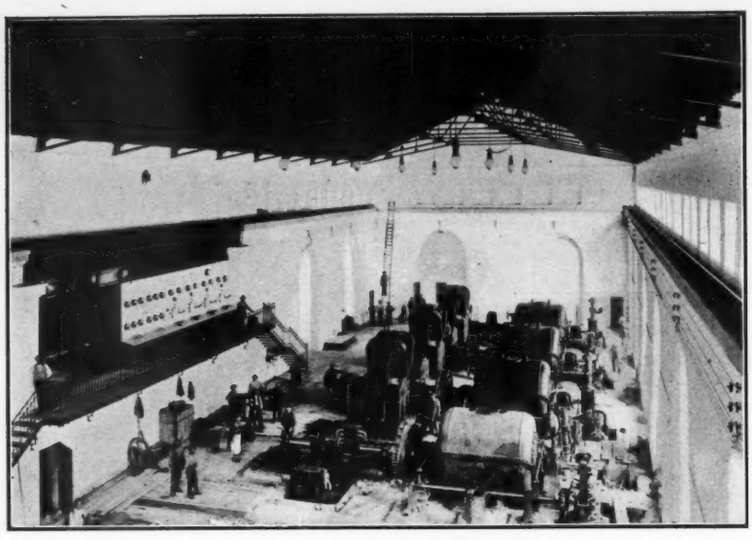
THE recent installations of polyphase railway and many power transmission plants in Italy by Ganz & Co., of Budapest, as well as other important installations for light and power, such as the Genoa series direct current high tension plant of the Thury system, of Geneva, Switzerland, which has been operating so successfully for a number of years (the energy being transmitted twenty-eight miles) show that Italy is not behind other countries in polyphase electrical development.



THE EXTERIOR OF THE PADERNO POWERHOUSE IS AS BEAUTIFUL AS ITS INTERIOR IS INTERESTING.

The Paderno-Monza-Milan transmission is one of the most important in Italy and is well worth consideration. The apparatus was supplied by the firm of Brown, Boveri & Co., of Baden, Switzerland, and it is of particular interest in that no step-up transformers are required, the high tension three-phase current of 15,000 volts being generated in the windings of the generators. The transmission line from the Paderno power house to Milan has a length of twenty-two miles, and the only transformers used are those of the static variety in the reducing stations at Monza and Milan. The Paderno generating station has a total capacity of 15,000 horsepower, and is equipped with seven direct-connected alternators and turbines of the types shown in the accompanying halftone illustration of the interior of a section of this power house. Each of the turbine alternators has a capacity of 2160 horsepower, and the regulators, shown at the right near the ends of the turbines, are said to operate with great precision. The turbines operate under a head of about eighty-two feet developing 2160 horsepower each with a flow of about 280 cubic feet of water per second. The turbines were installed by the firm of Riva Monneret & Co., of Milan. The regulation is said to be very satisfactory, controlling a normal load within 2 per cent. and a variation of 25 per cent. in load not to exceed 4 per cent. The governors were supplied by Ganz & Co., of Budapest. The plant is operated by the "Societa Generale Italiana di Elettricita of Milan, ' which has operated a steam plant for a number of years.

This latter consists of three direct-connected units of 1050 horsepower each. Three twin compound condensing steam engines are installed, each directly coupled to a polyphase generator of the Brown-Boveri type, having a stationary armature and a rotating field. There are also in this station three-phase generators



INTERIOR OF THE PADERNO POWERHOUSE.

supplying 15,000 volts directly without the use of step-up transformers. The exciters of the large direct-connected alternators are mounted on the ends of the engine and generator shafts outside of the main bearing.

The Paderno-Milan transmission line consists of three copper conductors, each of 354 mils diameter (No. 00 B. & S. gage), for each circuit. Each generator has a capacity of 1590 kilowatts, and when operated at 180 revolutions per minute supplies a current of 14,500 volts at a frequency of forty-two periods per second. This transmission is said to have been the first in Europe to use three-phase alternating currents of such a high tension generated direct in the windings of the generator, thus avoiding the use of step-up transformers.

The Milan converter station is equipped with machines of the Brown-Boveri type to the extent of 5900 horsepower, including two three-phase motors of 750 horsepower each and a number of motor-generators. The motor-generators are of the type shown in the illustration, and are for transforming the three-phase alternating current to direct current for lighting and traction work. There are in use in this converter station five motor-generators of 400 horsepower each and two additional machines of 100 horsepower each.

The Paderno installation, constructed in 1897 and 1898, stands out foremost among the great electric power transmissions of Europe, hence its detail is a matter which will be followed with both interest and profit by American engineers. The generators at Paderno each have an output of 73.5 amperes at 14,500 volts, and they yield 1850 kilovolt-amperes on a circuit of 80 per cent. power factor.

Through the courtesy of Mr. C. E. L. Brown, of Brown, Boveri & Co., there has been published* much interesting data concerning these machines as well as a full account of the insulation tests to which they were subjected. This data follows:

Armature Winding—Three-phase winding in Y-connection, 14 coils per phase. Per coil, 30 turns of 6-millimeter wire. Resistance of each phase, .76 ohm.

Field Winding—Twenty-eight coils in series. Per coil, 71 turns of copper strip on edge, 3 by 32 millimeters. Resistance of field coils, .46 ohm.

Mr. Brown writes about the tests on this machine:

"Before being put into the armature the micanite tubes were subjected to a six hours' test with a tension of 30,000 volts alternating applied between an iron tube placed inside the micanite tube and a cover of tinfoil on the outside of the tube—the length of the tinfoil covering being equal to the iron breadth of the armature. Tubes which heated during this test were rejected.

"After the generator had been erected we ran it for about five minutes with a tension of 21,000 volts by increasing the speed and exciting fully. We further carried out the following test with a special transformer: We opened the three-phase winding of a generator at the neutral point of the star connection and, whilst the machine was standing still, applied a tension of 30,000 volts on each pair of the three phases separately. We also applied a tension of 20,000 volts between frame and winding for one hour. All these tests were carried out without the slightest difficulty being experienced.

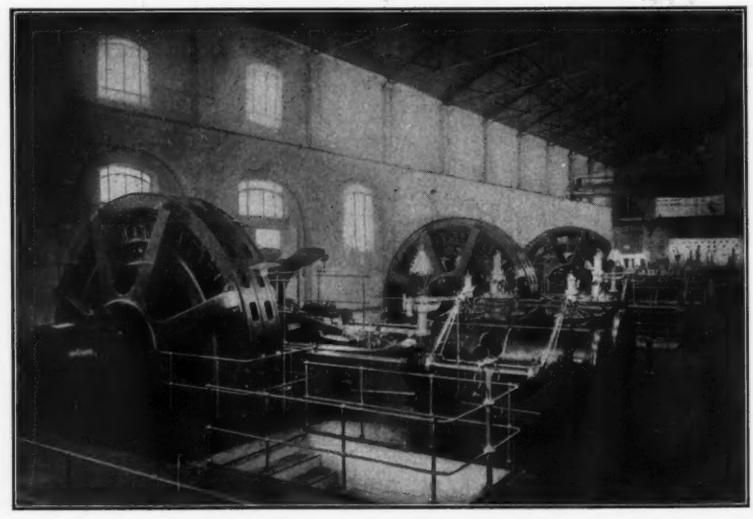
"In order to give you an idea of the excellence of the insulation, I will relate to you an accident which happened, and which really constitutes the best possible proof. One of the generators with its direct-coupled exciter was running fully loaded when the fuses blew, and as the turbine governor failed to act the speed rose to 1.7 to 1.8 times the normal. The excitation was not cut out until after one and one-half minutes, and, although the pressure went up to over 30,000 volts, not the slightest accident happened."

The losses of this generator if working on a non-inductive load are as follows:

	Watts.
Core loss	41,500
C^2R armature	9,000
Excitation	11,800
Total losses, excepting windage and friction	62,300
Windage and friction	20,500

The efficiency of direct-connected machines is generally figured according to the rules of the American Institute of Electrical Engineers, without the loss through windage and friction, giving an efficiency of 96.15 per cent. at full non-inductive load.

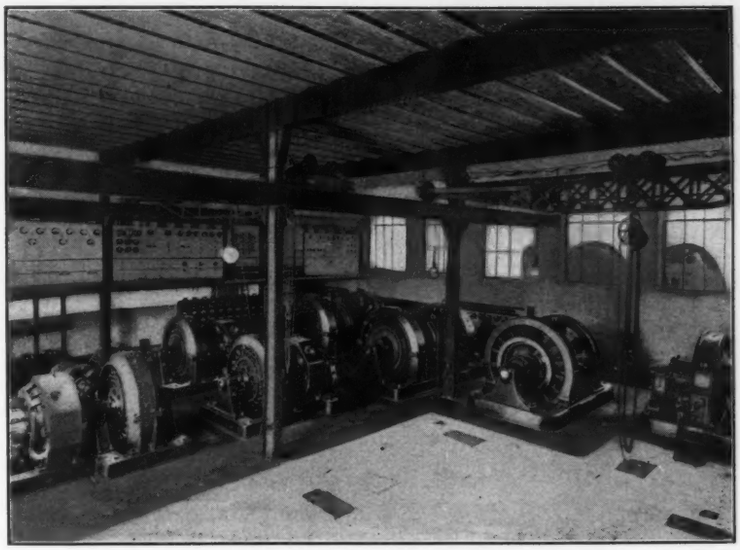
The Paderno water power plant operates in parallel with the steam plant at Porta Volta, in Milan. This plant was in operation before the Paderno installation was built. Both plants have operated for years in parallel without having given the slightest disturbance. The turbine governors in Paderno are equipped with electric motors that can be controlled from the switchboard



AUXILIARY STEAM PLANT AT MILAN.

*"The Debt of Electrical Engineering to C. E. L. Brown," by B. A. Behrend, in the *Electrical World and Engineer*, Volume XXXIX, page 212.

to distribute the load between the generators and to parallel them with greater facility. Mr. Brown seems never to have had trouble with "hunting" of alternators working in parallel. Steam engines of good design and the use of solid poles doubtless account for his having been spared these troubles. Furthermore his flywheel type is particularly well adapted to parallel running. In the case of the Paderno-Milano plant, the poles of the Porta Volta generators alone are solid, while the Paderno generators have laminated pole tips.



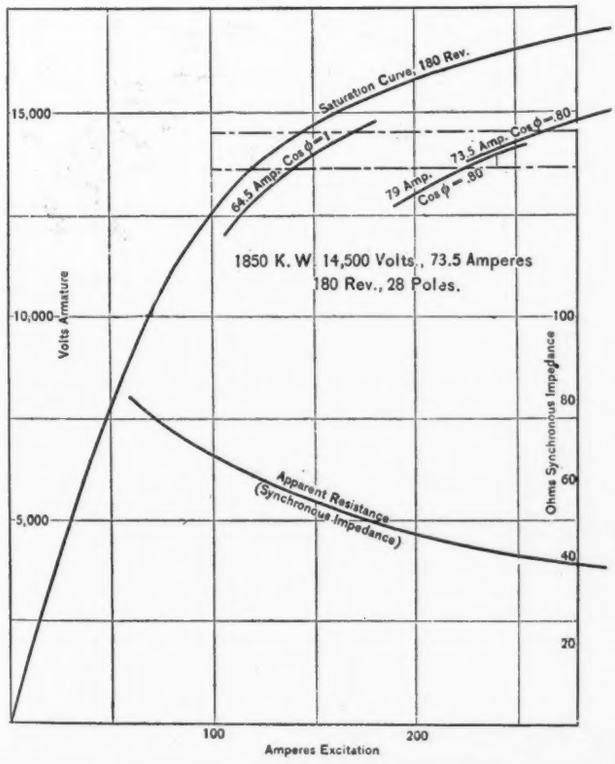
THE MILAN CONVERTER SUBSTATION.

UNITS OF WATER MEASUREMENT.

BY H. F. ROBINSON, C. E.

THE unit of water measurement in "Arid America" is by the general public assumed to be the "miners inch," but in ascertaining by actual measurement the amount of water flowing in a ditch or stream, the engineer uses as his unit a cubic foot of water per second, or, as it is often termed, the "second foot." A cubic foot of flow per second is that amount of water that would be delivered by a rectangular trough or flume one foot wide and one foot deep, running level full, the water moving at a uniform velocity of one foot per second. The miners inch is an uncertain quantity, differing in each locality, and is not, like the second foot, a definite quantity. Ask the question "What is a miners inch?" of a dozen different persons and you will get perhaps as many different answers. "The quantity of water flowing through an aperature one inch square, under a four-inch pressure," says one, or it may be five or even six-inch pressure. One will measure the pressure head from the top of the opening, another from the center; none will state whether the opening is with a thick or a thin edge, though a most important factor. Some of the States have by law defined a miners inch; others have not. The statutory inch in Colorado is defined as follows, viz.:

"Every inch shall be considered equal to an inch square orifice, under a five-inch pressure, and a five-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water."



CHARACTERISTICS OF THE PADERNO GENERATORS.

This inch is equal to forty-five cubic inches discharge per second, and thirty-eight and four-tenths of these inches are equal to one cubic foot per second. (See report State Engineer of Colorado, 1883–84.)

The California inch is equal to a flow of two-hundredths of a cubic foot per second, and one cubic foot per second, therefore, is equal to fifty miners inches. This is the amount under a four-inch head. The Idaho inch is the same as the Californian. In Montana forty statute inches are declared by law to be equal to one cubic foot per second. In Arizona there is no law in the statutes defining the miners inch. In a suit brought in the District Court before Judge Joseph H. Kibbey, in 1890, a miners inch was decreed to be one-fourtieth of a cubic foot flow per second. This having been adopted as the legal unit, all statements and contracts involving the measurement of water, when the terms are in inches, imply this definition of an inch.

Where the flow is controlled by a device of reasonable accuracy the inch as a unit is satisfactory to the public at large for the measurement of water in small ditches, but it is not suited to the measurement of rivers or large canals, as the devices prescribed for the measurement of the miners inch cannot be used on a large scale. For such measurements the cubic foot is of necessity the unit of measurement, though it may afterward be converted into the inch unit for the comprehension of those familiar only with that unit.

Both of these units are, however, for a continuous flow. It has been found in irrigation practice that a continuous flow is neither practicable nor desirable. This being the case, a unit of measurement that presupposes a continuous flow is not applicable to ascertaining the volume of water delivered. The ordinary measurement of volume, as the gallon, is too small to use for the purpose, so a new unit of measurement has been adopted, which is the acre-foot. This is the quantity of water that will cover one acre of land one foot deep, or 43,560 cubic feet of water. This is a convenient method of selling stored water, as the capacity of the reservoir can be measured by the same unit. For a smaller unit the acre-inch is sometimes used, which is the amount of water that will cover an acre an inch deep, or one-twelfth of an acre-foot. As yet, however, the acre-foot is not much used, except in computing the capacity of reservoirs.

PERSONAL.

Mr. Robert McF. Doble of San Francisco, Consulting Engineer, is in Mexico engaged in the examination of hydro-electric transmission projects in the interest of Eastern capitalists.

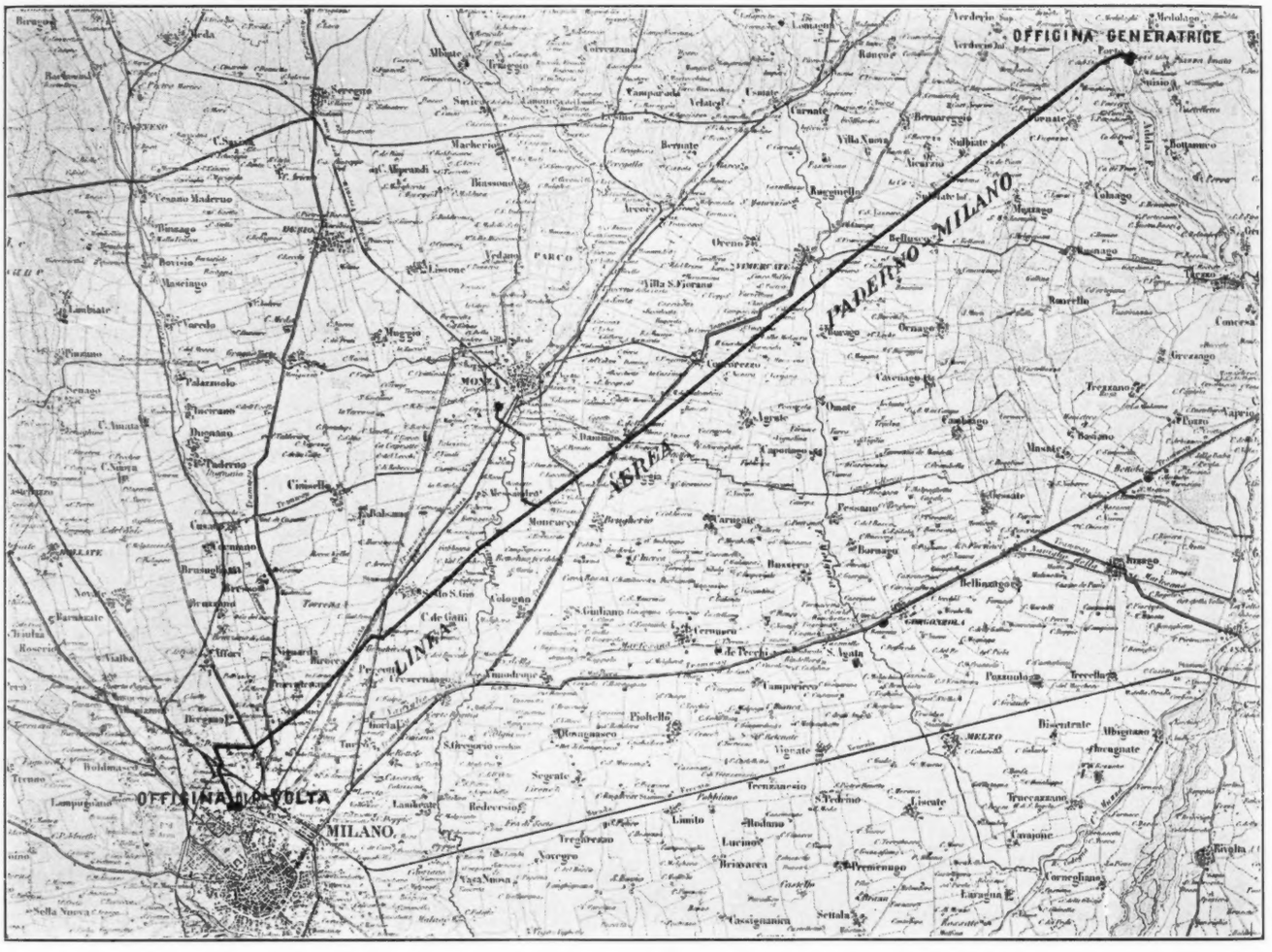
MUNICIPAL OWNERSHIP IN CALIFORNIA.

IT is but natural that the municipal ownership of public commodities should expand to a degree, albeit limited, in consonance with the growth of other developments toward the refinement of public service. In fact it is inevitable that however fallacious an idea may have been in practice, it is certain to be ventured with if it possesses an element of feasibility in theory. To this situation may be ascribed the status of municipal ownership of public utilities in California today, yet it is undoubtedly true that at no time has such conscientious, painstaking and intelligent effort been put forth toward the accomplishment of the success of municipal ownership as is being exerted at present. *California Municipalities* has been reviewing in brief summaries all the municipal enterprises which California cities and towns are engaged in, and given thereunder synopses of official reports rendered concerning costs, operating expenses and similar information of a general nature. The results will not be accepted by the managers of private corporations as reassuring, while on the other hand public officials may find them satisfying. Of this, however, we may be certain, municipal ownership has become an actual fact in California history, in view of which it is well to consider its reputed status.

According to the publication named*, electric lighting systems are owned by the following California municipalities, namely, Alameda, Anaheim, Colton, Healdsburg, Modesto, Palo Alto, Riverside, Redwood, Santa Clara, Santa Cruz and Ukiah, all of which, with the exception of Santa Cruz, have been acquired within the last ten years. In Redwood, Santa Clara and Santa Cruz the lighting systems are for street lighting only, no lights being furnished to private consumers.

The most complete and efficiently managed municipal lighting plant in the State is claimed to be at Riverside. In 1895 the city issued bonds to the amount of $40,000, and the proceeds were used to construct a receiving and distributing system and contracted with the Redlands Electric Light and Power Company to furnish electric current.* This system was added to from time to time until the investment amounted, in June, 1901, to $88,726.46. In 1900 the city issued additional bonds to the amount of $40,000 to build a steam power house for the purpose of generating electricity, and this plant cost, when fully completed to July 1, 1901, the sum of $43,784.19, making the total cost of the system to that date to be $132,510.65.

RIVERSIDE



SECTION MAP OF THAT PORTION OF NORTHERN ITALY TRAVERSED BY THE PADERNO-MILAN TRANSMISSION.

The following is published as a complete statement of the receipts and operating expenses during the year ending July 1, 1901:

Earnings of plant from June 30, 1900, to June 30, 1901—	
Light, power and wiring furnished private consumers.	$30,148.55
Incandescent lighting furnished city for street and office lighting—an equivalent of 2133 16 candle power for one month at 40 cents each per month..	853.20
Arc lighting furnished city on streets—an equivalent of 402 2000 candle power for one month at $4.00 each per month.....	1,608.00
Electrical supplies furnished city.....	53.90
Total earnings	$32,663.65

California Municipalities, Volume V, No. 4, page 103, November, 1901.

*See illustrated description in THE JOURNAL, Volume IV, page 21, May, 1897.

Operating expenses of plant from June 30, 1900, to June 30, 1901—

Electrical supplies for house wiring	$3,299.58
Incandescent lamps	867.71
Carbons	333.23
Salary and wages	7,131.41
Telephone rental	98.25
Horse and wagon; repairs and hire	146.40
Office supplies, postage and printing	143.30
Labor; experting books	61.50
Repairs	367.56
Power from Redlands: railway power not included	9,361.95
Power from Redlands for railway	1,547.04
Railway generator supplies	47.88
Water for transformers	150.00
Interest on bonds; receiving and distributing plant	1,750.00
Redemption of bonds, same	1,000.00
Sundries, same	31.11
Fuel, steam plant	2,238.80
Packing, waste and lubricating oil; steam plant	268.19
Water for boilers, steam plant	72.80
Repairs, steam plant	71.32
Sundries, steam plant	3.21
Interest on bonds, steam plant	1,600.00
Redemption of bonds, steam plant	1,000.00
Total operating expenses	$31,591.36
Total earnings	32,663.65
Excess of earnings over operating expenses	$1,072.20

"It will be seen from the foregoing report," states *California Municipalities*, "that the municipal plant of Riverside pays the operating expenses, interest and annual installment of debt, and returns a profit of over $1000 a year. No other municipal system in the State makes as good a showing."

ALAMEDA

In 1890 the city of Alameda issued bonds to the amount of $25,000 and purchased an existing plant from a private company. Money has been expended from time to time from the municipal treasury for the extension and improvement of the plant and the investment at the present time approximates $60,000. It has been charged, with some degree of truth, that this system has not been at all times efficiently managed, and the official reports show it to be the most expensively operated municipal plant of its size in the United States. The bookkeeping system has not been adequate and there is little data at hand to show the cost of the service. It is asserted, however, that the city is one of the best lighted cities of the country, and it is claimed that the cost of the service to the city is less than it would have been under private ownership. Lately steps have been taken to put the system upon an efficient and economical basis and a new accounting system has been inaugurated. Next year a more satisfactory report may be looked for.

PALO ALTO

The cost of the Palo Alto plant in 1899 was $18,000, of which amount $9000 was a surplus of a sewer bond issue of $40,000. It is operated in conjunction with a water works system and steam is taken from the same boilers. This plant is the only one in the State that reports the cost per unit of electricity generated. From a report made a year ago, the actual cost of light per kilowatt have average 7 cents, and this included interest and depreciation. Since the report was made (a year ago) the output has been considerably increased, so that the average cost approximates 6 cents per kilowatt hour. The price charged is 10 cents per kilowatt, so that the works return a fair profit. The capacity of the works has been reached and improvements must soon be made. The actual cost of arc lighting to the town is $40.32 per lamp per year running on a midnight moonlight schedule.

HEALDSBURG

The system operated by the municipality of Healdsburg is a combined water and lighting system, and the construction and operation of the two is so intermingled that it is impossible to separate them. The source of power is a number of large springs situated at a high altitude several miles from town. There is a good sized storage reservoir leading to the power house a mile or so distant. Here electric current is generated by Stanley three-phase alternators for the municipal lighting system, and power is also furnished to operate the pump for supplying water to the water system. The source of supply is from the underground channel and seepage from Russian river. The water is quite soft and pure and the supply is abundant. The cost of the combined system was $80,000, for which bonds were issued. The plant was completed in 1900. The first annual report was issued in June last and is as follows:

Received from sales of light	$5,123.25
Received from sales of water	4,066.95
Total cash received	$9,190.20
Water for sprinkling plaza	$120.00
Water for 43 hydrants	516.00
Water supplied Luce	60.00
Water supplied city hall	30.00
7,728,800 gallons sprinkling streets	772.88
Lights for city hall	269.40
Lights furnished Luce	20.04
Lights for streets, 31	2,704.00
Lights for streets, 32 candle power	70.00
Total benefit derived	$4,462.32
Total cash received	9,190.20
Total cash received and benefits	$13,652.52
Operating and repairs	$4,650.97
Extension and improvements	5,037.09
Total operation and repairs, extension and improvements	$ 9,688.06
Total cash received and benefits	13,652.52
Net profit to the city	$3,964.46

The amount of bonds issued was $80,000 and the interest charged was $3,825.

"It will be noticed that the table credits the benefits accruing from the use by the municipality of water and lights for public purposes and the rate charged is probably that which was heretofore paid by the city to private parties. Eliminating these items it will be seen that the profit over operating cost was about $4,500, which is sufficient to pay the interest charge and leave a surplus of $750."

OTHER PLANTS

In 1887 the city of Santa Cruz invested $5000 in electrical machinery to be operated in connection with its sewage pumping plant. It is used for street lighting only and about fifty arc lights are furnished. The operating expenses for an all night service is about $50 per light per year.

In 1897 Santa Clara invested $10,000 in a lighting plant to be operated in connection with its water system. It is for street lighting only, and forty-seven arc lights are furnished on a moonlight schedule until one o'clock. The cost of operating is $4.50 per month per light, including interest and depreciation. Santa Clara has the only municipal gas works in the State. It was completed last February at a cost of $30,000. Not having been in operation a year there is no data as to its operation.

Ukiah's system was installed in 1900 at a cost of $22,000. There is no detail as to cost of operation. Anaheim's system was installed in 1894 at a cost of $7000. It was added to in 1896. The income is about $4000 a year. No further details are at hand.

Redwood has a small plant for street lighting only, which is operated in connection with its water works. Colton's system was installed in 1896 at a cost of $6000. Modesto's system was leased, the rental at the same time applying on the purchase price.

It is to be regretted that there is so little data on the cost of producing electric current. In only one or two instances has any attempt been made to establish the cost per unit of energy. Until this be done there can be no intelligent comparison as to the relative effectiveness of the different plants.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

CONDUCTED BY GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Published monthly. Yearly subscription: Domestic, $1.00; Foreign, $1.50.
Subscriptions can not be begun with back numbers.
The price of single copies is variable.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

PUBLICATION OFFICE:
No. 536 Clay Street, ('Phone Bush 519), San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME XII MARCH, 1902 NUMBER 3

EDITORIAL.

OUR LATENT POSSIBILITIES.

It is good to see ourselves as others see us, especially when eyes among those of the keenest intellects of the world's greatest industrial and financial center are the medium for the looking. We of the far West are but frontiersmen along the borders of the knowledge we possess concerning the possibilities of our domain and concerning the attainments of our engineering. We do not know what a good thing we have got in this country of ours; we do not realize how the attention and energies of the whole commercial world are becoming centered upon our shores, nor do we appreciate the wonderment with which engineering achievements—regarded by us as already commonplace—have cast as spellbound the greatest intellects of far older communities. But if we do not have the full cognizance of the import of these matters, others have, and, as stated, it is good to know it, so that, in knowing it, we may bestir ourselves.

Thomas Commerford Martin, past president of the American Institute of Electrical Engineers, and the peer of any American journalist, technical or otherwise, has contributed an article to the current issue of the *American Monthly Review of Reviews* which shows well how the great West, and especially California, is talked about in the best magazines of today. Let us review Mr. Martin's article, even at the risk of redundancy along a single line of editorial comment, for it brings to us not necessarily that which we have forgotten, but more probably truths which we are so unfortunate, if not short sighted, as to fail to fully appreciate.

Mr. Martin first points out that that compensatory plan of providence which gave England her coal beds in lieu of sunshine has endowed California with one of the brightest climates in the world but left her without resources of fuel. Whether it is better for a country to live on its geology or its geography has remained hitherto a moot question, but usually coal mining regions have little to recommend them as places of residence after the deposits are exhausted. Newcastle and Pittsburg have no vogue as pleasure resorts; but long after their pits and volcanoes of pent up energy, hushed and empty, lie in black silence, picturesque Switzerlands and Californias will be drawing cheerfully upon the renewed bounty of the daily blue sky and fleecy cloud. The chief future of China appears to consist in its supply of black coal; but when that, in turn, is worked out, the melting glaciers of the Jungfrau, the bubbling streams of the snow clad Sierras, and the rushing tide of the Niagara gorge will still be here, to give up to us, not alone their beauty, but their strength. It is doubtless satisfactory to know that if you want warmth and light you can dig it up; but when the digging of the black coal dwindles, hand-to-mouth diurnal dependence upon sunshine and showers for the "white coal" that must largely take its place will be a mark of the highest economy and best efficiency on the part of our engineers.

Anthracite, bitumen, wood, gas and oil we are now burning up at a fine old rate; but even today, in spite of the cheapness that such a reckless exploitation of combustibles involves, great water power developments and transmissions have become established. Their success is already profoundly influencing many notable enterprises and some great regions, where all the conditions have been favorable but that of fuel supply. The two great plants in California to which Mr. Martin's article is devoted are being studied and imitated at points widely remote from each other in the two hemispheres, and results promise that are somewhat novel. Typical of such work is that in Mysore, India, or even more so that proposed at ancient Philæ, where the impounded waters of the Nile will submerge ancient temples of an outworn faith and make them sources of an illumination and culture quite other than were in the contemplation of the moldered priesthood. India as a center of factories; Egypt a leading cotton goods manufacturer; Switzerland, industrial heart of Europe; California and Chippewa sending out electric power for every wheel within five hundred miles—these and other noteworthy changes impend as the age of long distance power transmission begins with the new century.

Somehow or other, California has ever been graced with the spacious air of brave adventure to the Easterner and the European; and thus this latest event in her history, the putting into operation of the longest power transmission in the world, prosaic as it is in details, keeps gallant company with her romantic mission days, the brisker stirring and whip cracking of stock rangers, the fierce excitement of her gold discoveries, the splendid broadening of her wheat fields and orchards, the boldness of her irrigation ditches, and the princely magnitude of her unparalled

educational gifts. It must be something in the race, for where the Spaniard and the Mexican found the dreamy climate all too wooing to the "sweet doing of nothing" through the long afternoon of colonial existence, the strenuous Anglo-Saxon has pushed to every extreme of pioneership and achievement. A deadening Orient civilization besets the California shore with the damp Pacific breezes that fret the cypresses of Monterey; but the waiting Sierras catch their moisture, and in an instant transmute it into that irresistable electric current which is the expressive essence of Occidental science and progress.

For some years past, California has suffered in various respects from the dearness and absence of fuel; and the invitation to utilize some of the water power of her mountain ranges has always been urgent. The successful efforts at irrigation may be said to have led the way, and the State witnessed some of the earliest attempts of electrical engineers to transmit energy over long distances on a commercial basis, so that it is nothing new for them to have their attention concentrated on that spot. But until quite recently the limitations were rather severe. Obviously, except for mining, there would be little use of the current in the mountainous regions where it is generated; while, on the other hand, the cost and "loss" in the operation of the long lines that would put this energy beyond the pale of the foothills and within reach of the larger towns and coast cities were believed to be prohibitive. It is true that the great Niagara plant went into operation in the last decade, and, with all the lakes to draw upon as a reservoir, has been a pronounced success; but its present utility is within a striking distance of fifty miles. As late as September, 1896, Dr. Louis Duncan, a foremost authority, in his inaugural address as president of the American Institute of Electrical Engineers, remarked: "If we consider the record of the present transmission plants, we can safely say that it would not be going outside the safe limit of development to transmit at least fifty miles at a potential of 20,000 volts." Within five years, out here in California, we have increased the distance four times and raised the pressure three-fold—a record that would be fairly respectable in any branch of industry, and establishes an excellent start for the second century, whose predecessor began with Volta and with his little battery. Now, a circle around Niagara of fifty miles radius would not mean much to Rochester or Toronto; but radii of 220 miles in every direction from the Colgate power plant on the North Yuba River would include a region bigger than England. As it is, the lines of the allied Bay Counties and Standard systems shown on the map appearing on another page in this issue are already furnishing current for light, heat, power, chemical and metallurgical work, etc., in no fewer than sixteen counties, within whose borders lie one-half the population and three-fifths of the assessed valuation of the State. And these great California transmissions are not a temporary experiment like the 110 mile Frankfort-Lauffen of 1890, but a strictly commercial enterprise, attending to business all around the clock, every day in the year. Niagara also could, of course, send out its energy just as far, but industries and population at its very brink constantly intercept the supply, and apparently are basing upon it the nucleus of a vast productive city. This is, indeed, one of the most interesting power problems of the times. So far, none of the world's greatest cities has been built upon the coal measures or at the waterfalls; and it remains to be seen whether in the long run the people will go to Niagara or whether Niagara must come to the people. In California the problem is notably different, for the Sierras will always remain lonely, and San Francisco will always sit by the Golden Gate and multiply her children there.

With such words as these does Mr. Martin extol the wonders of electrical transmission engineering in California, and with words of similar purport other writers are telling the same story the world over. And why should not the accomplishments of our engineers and the glories of our possibilities as a great industrial and manufacturing mart of the future be extolled? The map on page 54 of this issue gives a suggestion of that which our engineers have accomplished, and the records of corporations recently formed tell of the development in the line of power distribution and application (for no locality can become a world's great manufacturing center without power in unlimited supplies) which the immediate future has in store.

Southern California is fast gravitating toward the unification of its transmission interests—why the electric lighting interests of Los Angeles have not seen the wisdom of burying their differences and merging their interests "for the good of the order" should not in common sense remain the greatest unsolved riddle of the day much longer. This combination effected, the unification of a trinity of the electric lighting and gas interests of Los Angeles with the transmission interests of Southern California would soon follow, after which will come further developments of as astounding a nature as are now being undertaken in the central portions of the State. The consummation of these ambitions will, of course, be delayed perhaps by the battle royal which seems to be brewing between rival electric railway systems in the City of Angels, for with the money of Senator Clark behind the Los Angeles Traction Company and the money of H. E. Huntington and others behind the Los Angeles Railway Company, to say nothing of the transcontinental lines which these companies may or may not represent, it is not presumable that peace is to be declared in a day.

Despite these difficulties, and despite the production of crude oil, the star of transmission progress in southern California is on the rapid ascendency, as it has ever been. The Edison Electric Company and the San Gabriel Electric Company, both of Los Angeles, look to transmission as their future source of power; the latter, through the Kern River Power Company, is making preliminary plans for bringing power from the Kern River across the Tehachapis into Los Angeles, and the Edison Electric

Company, through its five locations of water rights on the Kern River, proposes to bring power along the same route and to the same destination, despite its soon to be completed Mill Creek No. 3 station, with its 4000-horsepower. It is most significant that both these companies, although large consumers of steam power at present, do not regard the use of steam otherwise than as a temporary expedient. They are looking to transmission as their source of power, and this in spite of the fact that Los Angeles, the very city in which their power is being consumed, is the center of one of the greatest and oldest oil fields in the State. They have both tried and are using transmission, they have both tried and are using steam power from fuel oil, and though they are rival concerns, they both with one accord reach out to the mighty Kern, 120 miles away, as the source of power where present and future generations will satisfy their demands for mechanical energy. Hundreds of thousands of horsepower are there ever available, and tens of thousands of horsepower of it will find its way into Los Angeles within the next half decade.

Nor is central California napping, as reference in the columns of THE JOURNAL to its work in transmission will show. During the present month millions of Eastern money will be poured into San Francisco for the purchase of the principal of its street railway systems—henceforth to be known as the United Railways of San Francisco. Much of this money will find its way into new channels of industry, much will go into enterprises consuming power, and still more millions must come in to rejuvenate old methods into new ones; to make necessary extensions, and to modernize the system to the fullest degree. Besides it is, perhaps, possible that the manufacturing industries of San Francisco consume double the power which they did say five or six years ago. Shall San Francisco, removed as it is hundreds of miles from oil fields and thousands of miles from coal fields, find transmission wanting, when Los Angeles, with oil in unlimited quantities within its very borders, must go to the Kern River for its power?

Take the development of a single company, albeit a prominent one, and note well that its purports reflect the trend of power development, transmission and application of modern engineering to the fullest degree. The rise and unqualified success of the great companies engaged in long distance transmission in California is now a familiar story, but from one of the companies—the Bay Counties Power Company—a new concern of giant proportions has developed. This is the California Gas and Electric Corporation, which was incorporated on December 6th last with capital stock placed at the princely figure of $30,000,000. While the Bay Counties Power Company is reaching out, and, through its offshoot, the Valley Counties Power Company, is building stations which will add 8000-horsepower to its generating capacity before next winter; the California Gas and Electric Corporation, too, is reaching out and will in all probability eventually control not only the Bay Counties Company but also other properties which bear names that are familar household words. Tried, trusted and most competent officials are deserting positions that were almost sinecures in older companies in order that they may settle down to hard work under the enlightening banner of the new corporation, whose watchword is modernization and progression, and whose advent in every community marks its disenthrallment from old methods to new ones. Witness, for instance, the joy of the people of San Rafael, of Ross Valley, of Mill Valley, and of all the patrons of the Sausalito line to San Rafael over the purchase of the North Pacific Coast Railroad and over the work under way toward its equipment into a modern suburban electrical system second to none.

The Standard Oil Company is building a pipe line for carrying oil from the fields of Kern County to Point Richmond, on the Bay of San Francisco, a few miles above Oakland. It will be over 200 miles in length, and in many respects will be a remarkable piece of engineering. The California Central Gas and Electric Company, which is a member of the family of the giant corporation referred to, is centralizing the gas lighting systems of Santa Rosa, Petaluma and San Rafael, in Sonoma County, into a single station, to be located at Petaluma, and gas will be delivered to the other cities at high pressure from the Petaluma works. Similarly the California Gas and Electric Corporation, in an undertaking that is becomingly heroic, is reported in the daily press to be planning to construct a gas works at Bakersfield, to use the crude oil process for making water gas, having a capacity of 11,000,000 cubic feet per day, and whence will be supplied all intermediate cities in the San Joaquin Valley, to and including San Jose. This contemplates high pressure gas distribution for a distance of nearly 200 miles, and one of the clever engineering problems which its completion will enable to be worked out is whether it will be the more economical to deliver a given number of heat units to a point 200 miles distant from the oil fields in the form of gas made from crude oil, or in the form of the oil itself pumped that distance through a pipe line.

Nor does the progress and the development of California mark the progress and development of the great West, for the grand old State of Oregon and that youthful giant, the State of Washington, are forging into prominence by almost equally prominent strides. Engineers cannot be unmindful of the impetus that was given to transmission through the success which attended the efforts of P. F. Morey and his associates in delivering electric power from the Falls of the Willamette to Portland, fourteen miles away, almost fifteen years ago. Thus was begun the Portland General Electric Company, which has since become one of the sturdiest transmission corporations of the great Pacific Northwest. Snoqualmie, too, is not to be forgotten, not only for the interest centering in the plant itself, but for the fact that it is to be doubled in size, that it is to furnish power for the operation

of the new Seattle-Tacoma electric railway system, which, by the way, is now graded throughout and is ready for track laying (it is to be a third rail system throughout), and that it, with characteristic ambition, has applied for a franchise for the delivery of transmitted power in the city of Portland, some 180 miles from Snoqualmie Falls. Again, the city of Seattle, by a vote of 8200 for and 1500 against, has decided to build a municipal transmission from Cedar River Falls to Seattle, a distance of some fifty-eight miles, with a capacity of 2500-horsepower at the outset, although an estimated capacity of 25,000-horsepower is available.

And so the story goes, the story of the awakening to a realization of the latent possibilities and of the ultimate destiny of this far Western coast. When the world is thorougly awake to them, what will be the part that long distance transmission will play? Does any one who is conversant with that which transmission engineering has already accomplished doubt for a single instant that long distance electric transmission will form the mainspring of industry of this coming era?

THE CONSTRUCTION OF CHOKE COILS.

INFORMATION is often sought for regarding the construction of reactive or choke coils required to give a definite voltage with a given current and periodicity. The subject is very satisfactorily discussed in a London contemporary,* which points out that in order to answer this question fully it will be necessary to consider three more or less distinct types of choking coil, namely, those having a completely closed magnetic circuit of laminated iron as in figure 1; those having a magnetic circuit composed principally of iron, but including an air gap of definite area and length as in figure 2; and, lastly, those having adjustable

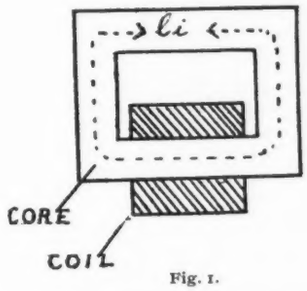


Fig. 1.

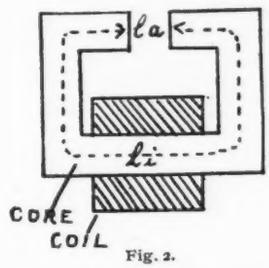


Fig. 2.

magnetic circuits variable from a complete or partial iron circuit into a complete or partial air circuit by withdrawing an iron core, as in figures 3 and 4. The closed magnetic circuit type is seldom

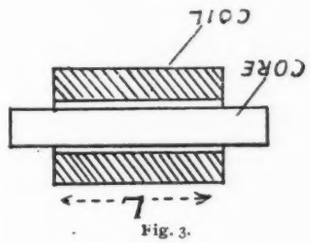


Fig. 3.

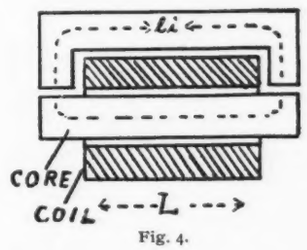


Fig. 4.

used in practice, since the physical relation of the permeability of iron to its hysteretic loss at a given density is such that the power factor cannot be reduced below about 5—*i. e.*, about 50 per cent. of the current through the coil × the volts across the coil are absorbed in the coil itself. The type shown in figure 2 would usually be used where no adjustment of the choked voltage is necessary, whilst, if a fair range of adjustment (say 2 : 1 or 3 : 1) is required, figure 3 would be used, and for a still larger range figure 4 would be found most suitable.

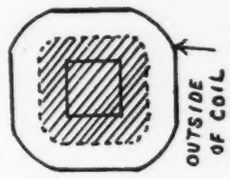


Fig. 5.

When the type to be used has been decided upon, the next point is to obtain the best size of iron core—*i. e.*, the size of core for which the combined price of copper and iron (with a reasonable temperature rise) shall be a minimum, except in a few special cases in which efficiency is of more importance than price. No general rule of a simple nature can be given for obtaining this size, so that it must be approximated to by a trial and error process, as described below. This, however, will be found to give little trouble, since considerable variation is permissible without greatly influencing the total cost.

Let C = the given current passing through the coil (square root of the mean square ($\sqrt{MS}$) value);
V = the given volts to be measured across the terminals of the coil when the current, C, is passing;
$\frown$ = the given periodicity;
T = the number of turns in the coil;
S = the net section of iron in the core, in square inches;
B = the permissible flux density (maximum value) in the core —this depends on the quality of the iron and the readiness with which the core can cool itself, and should lie between 40,000 and 60,000 C.G.S. lines per square inch at ordinary periodicities;
N = average total flux which must pass through every turn of the coil in order that the volts, V, may be read at the terminals; = B × S.

Having assumed tentative values for the section of core, S, and the induction density, B (and therefore N), two independent expressions for the number of turns, T, are available, one depending on the number of volts, V, and the total flux, N, and the other depending on the current, A, and the reluctance of the magnetic circuit. The process of designing a choking coil consists practically in so adjusting the different variables that the two values of T obtained from these two expressions shall be alike.

The first expression is merely the ordinary transformer formula:

$$T = \frac{V \times 10^8}{4{\cdot}44 \times N \times \frown},$$

whilst the second varies with the type of choking coil under consideration as follows:

1. For the complete iron circuit type (figure 1)—

$$T = \frac{l_i \times X}{\sqrt{2}},$$

where l_i = the mean length of the iron circuit, in inches;
X = the ampere turns per inch of iron at the density, B, and is obtained from a permeability curve of the particular quality of iron used.

2. For the partial iron, partial air circuit type, shown in figure 2—

$$T = \frac{(l_i \times X) + (\cdot 3132 \times \frac{N}{a} \times l_a}{\sqrt{2} \times C},$$

where l = mean length of the iron part of the circuit, in inches;
X = ampere turns per inch of iron;
a = effective area of the air gap, in square inches (taken at right angles to the direction of the flux);
l_a = length of air gap from iron to iron, in inches;

3. For the moveable straight core type (figure 3), two extreme cases occur—

(*a*) When the iron core is placed centrally within the coil,

$$T = \frac{N \times \cdot 175}{C \times \sqrt{D}},$$

The Electrical Engineer, London, Volume XXVII, page 168, February 1, 1901.

(*b*) When the iron core is entirely withdrawn

$$T=\frac{N_1}{C_1}\left(\frac{\cdot222\times L}{A}+\frac{\cdot125}{\sqrt{A}}\right),$$

where N = the flux corresponding to the maximum volts, V, which the coil is to choke with current, C, passing;

N_1 = the flux corresponding to the minimum volts, V_1, which the coil is to choke with current, C_1, passing;

A = the area in square inches of one end face of the coil taken to the center of the winding space (= the shaded area in figure 5);

D = the total superficial area in square inches of those parts of the iron core which project beyond the coil at both ends, including top, bottom, side and end faces so far as they project beyond the coil. (Note—If the core ends are flush with the ends of the coil D = 2 S practically);

L = length of coil, in inches.

In the formula (*b*) the first term within the bracket is proportional to the magnetic reluctance of that part of the magnetic circuit lying within the coil, whilst the second term is proportional to the external reluctance. A little consideration will show that, in order to obtain a large range of voltage, the winding should be arranged in a long and shallow coil, and with the central iron core of small section and projecting beyond the coil to a considerable distance (say as much as one-quarter the length of the coil) at each end.

This formula is based on a paper by Mr. Evershed, which has been found to give quite satisfactory results in practice.

4. For the special case of (3) shown in figure 4, the two formulæ would be:

(*a*) When the central core is in the coil, thus forming a complete iron circuit,

$$T=\frac{l_1\times X}{\sqrt{2}\times C}$$

X being the number of ampere turns per one inch of iron corresponding to the maximum flux, N.

(*b*) When the central core is completely withdrawn, but the outer core left in position,

$$T=\frac{N_1\times L\times\cdot222}{C_1\times A}$$

In conclusion, it must be remembered that when a choking coil is introduced into a circuit the net remaining voltage available in the circuit cannot be got by simply subtracting the voltage measured across the coil from the supply voltage, for phase shifting is present, and the correct result can only be obtained by a vectorial sum. Thus, if the rest of the circuit is non-inductive (such as an incandescent lamp load would be), the net remaining voltage across the lamps is given by $\sqrt{E^2-V^2}$, where E is the total supply voltage and V is the voltage across the choking coil. If, however, the load is not non-inductive, but has a power factor $=\cos\phi$ less than 1, the summation is best made by means of such a diagram as figure 6. The line O H represents the current in phase.

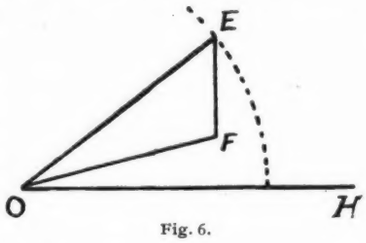


Fig. 6.

Draw the line O F at the angle ϕ to line O H, and of such a length as to represent to any scale the required remaining voltage with the choking coil in circuit. Then draw an arc of a circle with center, O, and radius equal to the total supply voltage to the same scale. Draw a line from F at right angles to line O H. This will cut the semicircle of some point, E. Then, neglecting volts lost in the resistance of the coil, F E is the required voltage which must exist across the choking coil terminals in order to reduce a supply voltage, O E, down to an available voltage, O F.

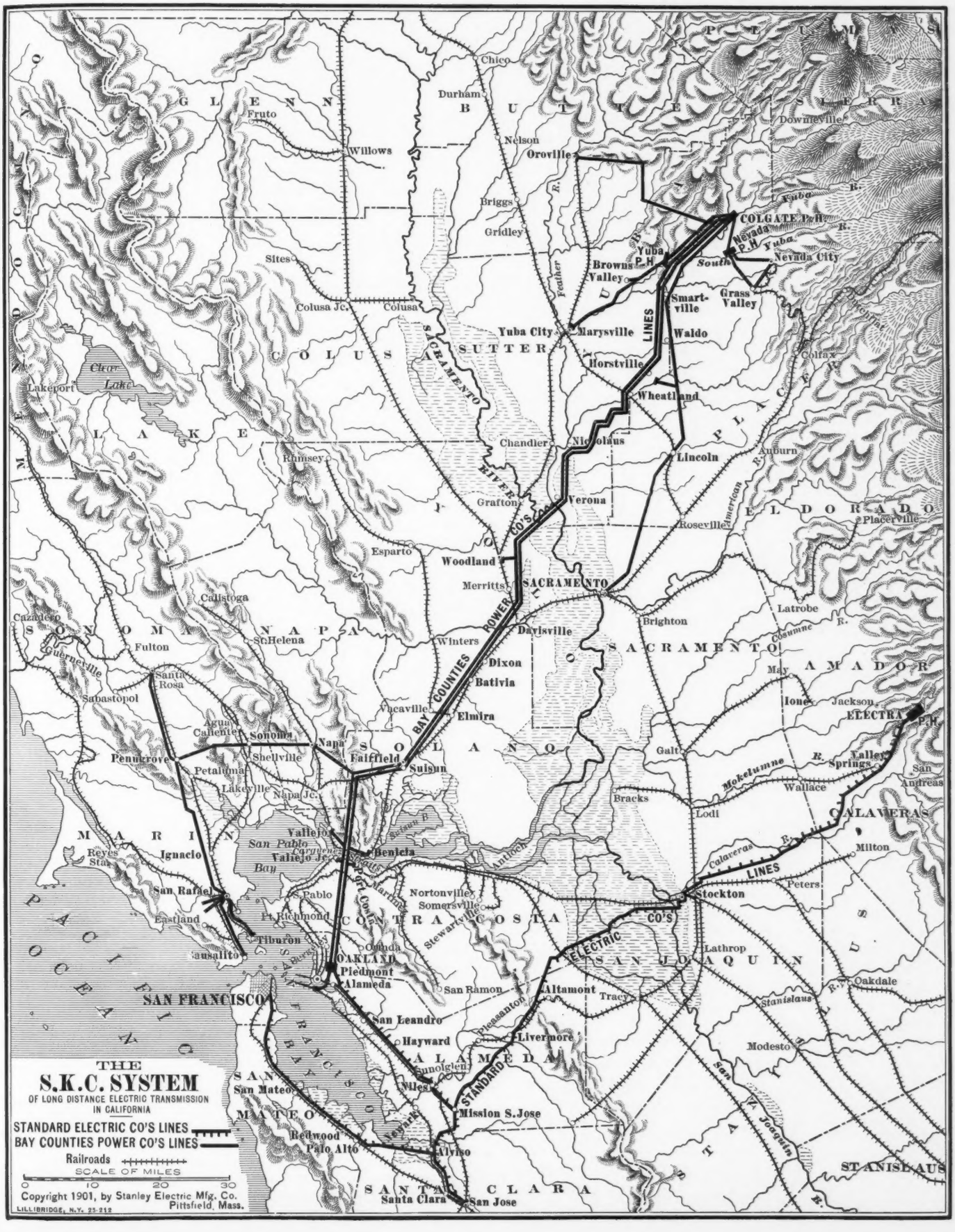
COMPRESSED AIR FOR PUMPING PLANTS*.

FOR convenience in figuring on large pumping plants to be operated by compressed air, there is given herewith a table by which the pressure and volume of air required for any size pump can be readily ascertained. Reasonable allowances have been made for loss due to clearances in pump and friction in pipe.

To find the amount of air and pressure required to pump a given quantity of water a given height, find the ratio of diameters between water and air cylinders and multiply the number of gallons of water by the figure found in the colume for the required lift. The result is the number of cubic feet of free air. The pressure required on the pump will be found directly above in the same column. For example: The ratio between cylinders being 2 to 1. Required to pump 100 gallons, height of lift 250 feet. We find under 250 feet at ratio 2 to 1 the figures 2.11; 2.11×100=211 cubic feet of free air. The pressure required is 34.38 pounds.

Ratio of Diameters.	PERPENDICULAR HEIGHT, IN FEET, TO WHICH THE WATER IS TO BE PUMPED.															
	25	50	75	100	125	150	175	200	225	250	300	350	400	450	500	
1 to 1	13.75	27.5	41.25	55.0	68.25	82.5	96.25	110.0	.....	.....	.....	.....	.....	.....	.....	Air pressure at pump.
	0.21	0.45	0.60	0.75	0.89	1.04	1.20	1.34	.....	.....	.....	.....	.....	.....	.....	Cubic feet of free air per gal. of water.
1½ to 1	.....	12.22	18.33	24.44	30.33	36.66	42.76	48.88	55.0	61.11	73.32	85.4	97.66	.....	.....	Air pressure at pump.
	.....	0.65	0.80	0.95	1.09	1.24	1.39	1.53	1.68	1.83	2.12	4.41	2.70	.....	.....	Cubic feet of free air per gal. of water.
1¾ to 1	.....	.....	13.75	19.8	22.8	27.5	32.1	36.66	41.25	45.83	55.0	64.16	73.33	82.5	.....	Air pressure at pump.
	.....	.....	0.94	1.14	1.24	1.30	1.54	1.69	1.84	1.99	2.39	2.59	2.83	3.19	.....	Cubic feet of free air per gal. of water.
2 to 1	.....	.....	.....	13.75	17.19	20.63	24 06	27.5	30.94	34.38	41.25	48.13	55.0	61.88	68.75	Air pressure at pump.
	.....	.....	.....	1.23	1.37	1.52	1.66	1.81	1.96	2.11	2.40	2.69	2.98	3.28	3.57	Cubic feet of free air per gal. of water.
2¼ to 1	.....	.....	.....	.....	13.75	16.5	19.25	22.0	24.75	27.5	33.0	38.5	44.0	49.5	55.0	Air pressure at pump.
	.....	.....	.....	.....	1 533	1.68	1.83	1.97	2.12	2 26	2.56	2.85	3.15	3.44	3.73	Cubic feet of free air per gal. of water.
2½ to 1	.....	.....	.....	.....	.....	13.2	15.4	17.6	19.8	22.0	26.4	30 8	35.2	39.6	44.0	Air pressure at pump.
	.....	.....	.....	.....	.....	1.79	1.96	2.06	2.104	2.34	2.62	2.88	3 18	3.36	3.23	Cubic feet of free air per gal. of water.

*By Permission from Catalogue No. 10, on "Pumping Machinery," of the Risdon Iron Works, San Francisco.


THE
S.K.C. SYSTEM
OF LONG DISTANCE ELECTRIC TRANSMISSION
IN CALIFORNIA
STANDARD ELECTRIC CO'S LINES
BAY COUNTIES POWER CO'S LINES
Railroads
SCALE OF MILES
0 10 20 30
Copyright 1901, by Stanley Electric Mfg. Co.
Pittsfield, Mass.
LILLIBRIDGE, N.Y. 25-212
COLGATE P.H.
Nevada P.H.
Yuba P.H.
Nevada City
Grass Valley
Smartville
Marysville
Yuba City
Waldo
Wheatland
Nicolaus
Lincoln
Auburn
Colfax
Placerville
Roseville
Verona
Grafton
Chandler
Woodland
Merritts
SACRAMENTO
Davisville
Winters
Dixon
Batavia
Elmira
Vacaville
Brighton
Latrobe
Galt
Ione
Jackson
ELECTRA P.H.
Valley Springs
Wallace
San Andreas
Lodi
Bracks
Milton
Peters
Stockton
Lathrop
Oakdale
Modesto
Stanislaus
Tracy
Altamont
Livermore
Pleasanton
San Ramon
Hayward
San Leandro
Mission S. Jose
Alviso
Santa Clara
San Jose
ST. ANISLAUS
Oroville
Chico
Durham
Willows
Fruto
Orland
Sites
Colusa
Colusa Jc.
Clear Lake
Lakeport
Rumsey
Esparto
Calistoga
St. Helena
Fulton
Santa Rosa
Sebastopol
Guerneville
Cazadero
Agua Caliente
Sonoma
Shellville
Napa
Fairfield
Suisun
Petaluma
Penngrove
Lakeville
Napa Jc.
Vallejo
Vallejo Jc.
Benicia
Reyes Sta.
Ignacio
San Rafael
Tiburon
Sausalito
Pt. Richmond
Eastland
Pablo
Nortonville
Somersville
Stewartville
Oakland
Piedmont
Alameda
San Francisco
Redwood
Palo Alto
Niles
Irvington
Centerville
Newark
Mayhews
Martinez
Antioch
Calaveras
Mokelumne
Cosumne
American
Yuba
Feather
Sacramento
Bay Counties Power Co's Lines
Standard Electric Co's Lines
Smartville Lines
Electric Co's
Standard Electric Co's
Pacific Ocean
San Francisco Bay
Suisun Bay
Carquinez Straits
Golden Gate
Lake
Glenn
Colusa
Sutter
Butte
Plumas
Sierra
Yuba
Placer
El Dorado
Amador
Calaveras
Sonoma
Napa
Solano
Marin
Contra Costa
San Joaquin
Alameda
San Mateo
Santa Clara
Stanislaus

An Extraordinary Composite Pole Line System.

WHILE complete descriptions of the pole line systems of the Standard Electric Company and the Bay Counties Power Company have been published in these columns heretofore,* it is still a very instructive object lesson to have presented on a single page a composite map showing the extraordinary pole line system which has resulted from the temporary exigencies that have caused these two record breaking systems to be joined together into a single one of mastodonic proportions. At present the much talked of transmission is, therefore, a combination of these two systems, and it extends from the Colgate powerhouse, on the Yuba River, in Yuba County, clear through to Stockton by way of Oakland and Mission San Jose.

Through the courtesy of the Stanley Electric Manufacturing Company there is published on the preceding page an excellent map of these two great systems, and the pole lines thereon are entirely finished and ready for operation, while all of them are in actual commercial service twenty-four hours daily, except the stretch of forty-six miles from Stockton to the Standard Company's power house at Electra, and the line from Redwood City to San Francisco, a distance of thirty-two and one-half miles. During the coming month the San Francisco substation of the Standard Company will be finished and power will be transmitted into San Francisco from Colgate, 212 miles distant, while the early completion of the Standard power house at Electra will cause the line between Stockton and Electra to be put into service.

The distances covered by these pole lines are as follows:

From Electra to Stockton, 46 miles. One circuit, 471,034 c. m., aluminum cable.

From Stockton to Mission San Jose, 49.6 miles. One circuit, 471,034 c. m., special aluminum cable.

From Mission San Jose to Oakland, 26.3 miles. One circuit, 188,230 c. m., special aluminum cable.

From Alviso to San Jose, 8½ miles. No. 1 B. & S. gage aluminum solid.

From Mission San Jose to Alviso, 9½ miles. One circuit, 352,300 c. m., aluminum cable.

From Mission San Jose to Redwood City, 16.3 miles. One circuit, 352,300 c. m., aluminum cable.

From Redwood City to San Francisco, 32½ miles. One circuit, 352,300 c. m., aluminum cable.

From Electra to Oakland, 122 miles. One circuit, 352,300 c. m., aluminum cable.

From Electra to San Jose, 113.6. One circuit, 352,300 c. m., aluminum cable.

From Electra to San Francisco, 153.9 miles.

From Colgate to Oroville, 28 miles. One three-phase circuit of No. 4 aluminum cable.

From Colgate to Nevada County power house, 7 miles. Two three-phase circuits.

From Colgate to the old Yuba power house, 8 miles. Two three-phase circuits of No. 4 aluminum cable.

From old Yuba power house to Marysville, 18¾ miles. Two three-phase circuits of No. 6 copper.

From Colgate to Sacramento, 61 miles. Two three-phase circuits of No. 4 aluminum cable.

From Colgate to Oakland, 132 miles. Two three-phase circuits. North circuit of No. 00 B. & S. gage copper; south circuit of No. 0000 B. & S. aluminum cable, Colgate to Suisun, and No. 00 B. & S. gage copper, Suisun to Oakland.

From Colgate to Cordelia, 107 miles.

From Cordelia to Penn Grove, 26 miles. One three-phase circuit of No. 4 B. & S. gage three-strand aluminum cable.

From Penn Grove to Sausalito, 32 miles. One three-phase circuit of No. 4 B. & S. gage three-strand aluminum cable.

From Penn Grove to Santa Rosa, 13 miles. One three-phase circuit of No. 4 B. & S. gage three-strand aluminum cable.

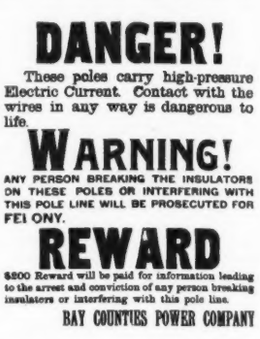
From Colgate to Sausalito, 165 miles.

From Colgate to Stockton, 208 miles.

From Colgate to San Francisco, 211¾ miles.

*THE JOURNAL for August last, now out of print.

As to the poles themselves, those used on the Bay Counties' lines are uniformly of the round cedar variety throughout the whole system. They were selected with great care from the best timbered sections of the Columbia River and its tributaries, whence comes the best of round cedar poles probably to be found in America. These poles are known as the round red cedar of Oregon, and are especially noted for their strength and lasting qualities in the ground, being far superior to any other kind of cedar on the Pacific Coast. This cedar has an average life of about thirty years for ground work, and is fast becoming popular with many large power plants. Great care is taken in the selection of them, in order that nothing but live trees should be used, and they were cut and trimmed during the fall and wniter months, which is the best time. These poles are generally left in the woods for months after being cut, and, after being properly barked when green and thoroughly dried, are floated down the stream during the freshets of the spring to some convenient point of shipment, which is done either by vessel or by rail. To some who are not fully posted in the appearance of round cedar, it may be a surprise to know that often the roughest, toughest and most unattractive appearing poles are the ones that will last the longest in the ground, and which are, consequently, the most desirable. The unattractive appearance is frequently caused by "winter barking," which is much more apparent in the fall and winter months, when the sap is out of the trees, than it is during the spring and summer, in consequence of which an inner bark is frequently left around the wood. This gives the pole a rough and unattractive appearance, but it can always be easily removed by the free use of the draw-knife; in fact the use of the draw-knife should never be spared on any pole, as it is needed for appearance as well as for strength.


DANGER!
These poles carry high-pressure Electric Current. Contact with the wires in any way is dangerous to life.
WARNING!
ANY PERSON BREAKING THE INSULATORS ON THESE POLES OR INTERFERING WITH THIS POLE LINE WILL BE PROSECUTED FOR FELONY.
REWARD
$200 Reward will be paid for information leading to the arrest and conviction of any person breaking insulators or interfering with this pole line.
BAY COUNTIES POWER COMPANY
THIS NOTICE IS TACKED ON ALL BAY COUNTIES' POLES.

In the shipment of round cedar poles great care is taken in their inspection, and nothing is shipped but that which is first-class in every particular. The firm of Lindsley Bros. Company, of Portland, Or., are the largest dealers in this class of Oregon red cedar poler, and the major portion of the poles used on the Bay Counties' system was supplied by them. The members of this firm are experienced pole men, and allow nothing to leave their yards which has not passed three inspections, namely, inspection of the poles as they are taken from the woods at the point on the river, inspection at the yards upon delivery, and for a third time when being loaded on cars for shipment. The California business of the Lindsley Bros. Company is now handled by Messrs. George E. Carter & Co., of San Francisco. The Bay Counties' poles are in the following sizes:

HEIGHT.	TOP.	BUTT.	DEPTH IN GROUND.
25 feet	8x8	12x12	5 feet
40 feet	9x9	14x14	6 feet
45 feet	10x10	15x15	6½ feet
50 feet	11x11	16x16	7½ feet
60 feet	12x12	18x18	8 feet

The features of the pole line system of the Standard Electric Company has been described so fully by Mr. C. O. Poole in his paper read before the San Jose convention of the Pacific Coast Electric Transmission Association,* that little, if anything, further can be written in relation to it. The poles, which were furnished by the Union Lumber Company, of San Francisco, are all of the sawed redwood variety and were taken from the hearts of young

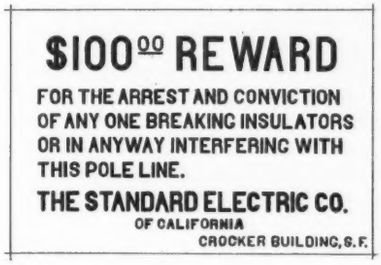
*THE JOURNAL, Volume XI, page 185 *et seq.*, August, 1901; also Transactions of the Fifth Annual Convention Pacific Coast Electric Transmission Associan, page 99.

trees. Not more than four poles were taken from any single tree, there being no sap whatever in the finished poles. The heights and sizes, together with the depths to which the poles are placed in the ground, are as follows:

HEIGHT AND SIZE OF POLES USED BY THE STANDARD ELECTRIC COMPANY.

HEIGHT.	TOP.	BUTT.	DEPTH IN GROUND.
30 feet	7x7	12 x12	5 feet
35 feet	7x7	13½x13½	5 feet 6 inches
40 feet	8x8	13½x13½	6 feet
45 feet	9x9	15 x15	6 feet 6 inches
50 feet	10x10	16 x16	7 feet
60 feet	11x11	17 x17	8 feet

It should be added that in addition to the lines shown on the map, the Standard Electric Company is operating a three-phase line extending along the mother lode from Angels, in Calaveras County, to Amador City, four miles above Jackson, in Amador County. This line, which constitutes the old Blue Lakes circuit, is at present being operated from the old Blue Lakes power house, and consists of a three-phase circuit of No. 3 B. & S. gage copper wire, the Calaveras circuit, extending from the power house to Angels by way of San Andreas being thirty-one miles long, while the Amador circuit, which takes in Jackson, Sutter Creek and Amador City, with the scores of neighboring mines, is about fifteen miles in length. Further extensions are being made by the Standard Electric Company in southerly and southwesterly directions from San Jose, and through the Suburban Electric Light Company of Oakland, Cal., secondary distribution at 4000 volts is being made through all the thickly settled fruit growing and suburban residence districts from Fruitvale (a suburb of Oakland) down to Alvarado and Newark, including San Leandro, Haywards, Sunol, Niles, Mission San Jose and Alviso. Indeed, the business of the Suburban Electric Light Company promises to become of the best properties in the way of the smaller electric power distribution companies in the State.


$100.00 REWARD
FOR THE ARREST AND CONVICTION OF ANY ONE BREAKING INSULATORS OR IN ANYWAY INTERFERING WITH THIS POLE LINE.
THE STANDARD ELECTRIC CO.
OF CALIFORNIA
CROCKER BUILDING, S.F.

AND THIS ON ALL STANDARD ELECTRIC COMPANY'S POLES.

Referring to the Bay Counties' system, the line for the transmission of electric service into Napa, Sonoma and Marin Counties leaves the main line to Oakland at Cordelia (not noted by name on the map). The steam plants at Santa Rosa, San Rafael and Sausalito have been shut down permanently, while that at Petaluma will probably be enlarged and continued in service as an auxiliary. In addition, a great gas plant is being built at Petaluma, and as soon as it is finished gas service will be delivered to Santa Rosa, San Rafael, Sausalito, San Quentin and intermediate localities from the Petaluma station by means of high pressure gas distribution. Further than this, the North Pacific Coast Railroad system, operating a narrow gage steam line from Sausalito through the redwoods along the coast to Cazadero, has been absorbed by the owners of the Bay Counties' system, and the work of converting the local suburban steam railway service between Sausalito and San Rafael into a modern suburban electric railway system has already begun. This will throw a very heavy load on to the Colgate power house at the very end of a transmission line 165 miles in length.

In the meantime the engineering department of the Bay Counties' system is reaching out for more power, and its first efforts in the way of further development will be at Cherokee and at French Creek, in Butte County. These new sources of power will come from the country contiguous to the Big Bend region of the Feather River, so famous in mining circles in California, and the new power house will be tied in directly with Colgate, which will necessitate in all some eighty miles of additional pole lines. The preliminary work for the new installation is well under way, and the management of the system is confident that an additional 8000-horsepower in electric energy will be delivered to the Bay Counties' lines at Colgate before the heavy load of the coming winter shall be thrown upon the system.

In view of these extensions, absorptions and developments it is well to realize that another map will be in order for publication within a year, and that when it does appear the two great systems now described will have become regarded as being but the neucleii of a monster transmission network that, tentacular like, shall cover practically the whole of northern and central California.

*Static Strains in High Tension Circuits.**

BY PERCY H. THOMAS.

IT is the purpose of the present paper to discuss the so-called "static effects" in high tension circuits, especial attention being given to the disturbances produced by lightning, switching, grounding and the like. Some discussions of particular phases of the principles involved have appeared from time to time, but so far as has come to the attention of the author, no comprehensive treatment of the subject of a non-mathematical character has so far appeared. On this account a general view of the question without mathematical complication will probably prove of interest to superintendents and station managers as well as to electrical engineers. Necessarily much of the matter in the paper will not be new, but it will be found that the old principles when applied to commercial circuits yield quite novel and important results.

It is scarcely necessary to state that static strains, though not perhaps particularly destructive of themselves, may indirectly cause the loss or temporary disabling of expensive and important apparatus; and more is involved than the loss of the apparatus. One of the principal aims, if not the chief aim of the superintendent of a modern electric transmission system, for the accomplishment of which he will make great sacrifices, is to keep his service continuous. Static disturbances in such systems, when not properly controlled, are a constant menace to the continuity of the service. The prominence of static effects is one of the chief distinguishing characteristics of high tension operation. The importance of "static" is not emphasized solely on theoretical grounds. Plants in actual operation have suffered both damage to apparatus and loss of prestige on account of insufficient static protection. The paper will be divided into two parts:

I. Nature, Causes and Effects of "Static" Disturbances; and
II. The Protection of Apparatus and the "Static Interrupter."

PART I.

NATURE, CAUSES AND EFFECTS OF STATIC DISTURBANCES.

INTRODUCTORY.

The term "static" is certainly a misnomer, as the most prominent characteristic of the phenomena thus designated is the abrupt and violent nature of their discharges of electricity. However, this group of phenomena is so clearly defined and is so generally recognized by this name that in the absence of a better term of general acceptance its use will be continued. A new term, however, is very greatly to be desired, and as the phenomena described are essentially those of wave motion, the author recommends the word "undic" as a substitute for "static."

*A paper read at the 161st meeting of the American Institute of Electrical Engineers, New York, February 14, 1902.

For the present discussion "static" (or "undic") will be taken to include those changes of potentials and waves of current of an abrupt nature which result from the transfer of the electrostatic charges of a system from point to point. Such actions are not directly produced nor controlled by the generator. I say "not directly," for, of course, practically all electrical phenomena in a circuit, except those due to lightning, are produced at least indirectly by the generator.

Every electric circuit may be viewed in two ways. It may be regarded (as in dealing with the transmission of energy) as a closed circuit containing resistance and inductance and carrying a certain current produced by a certain electromotive force, or it may be regarded (as in dealing with static) as a large insulated "conductor" (as the term is used in treatises on static electricity) of peculiar form. That is, the circuit performs a double function. It transfers useful energy and at the same time acts as an electric condenser. The first aspect, being the one of greatest practical importance, is the one almost universally considered. However, even in this case, with long high tension lines, it has been found necessary to give some attention to the electrostatic capacity of the circuit taken as an insulated "conductor." The second aspect of the circuit is the one to be here considered, and though of less importance than the first it still deserves careful consideration on account of the serious difficulties static may cause in commercial work. As a matter of fact, since the electric circuit when operating is at the same time both a closed circuit carrying current and a charged insulated "conductor," the actual resultant condition of the system is a combination of these two states.

There are some points of difference, however, between the commercial electric circuit and the insulated "conductors" commonly used in the laboratory demonstrations of static electricity. In the first place the commercial circuit is very much the larger and is extended over greater distances, so that a sensible time is required for an electric impulse to pass from one end to the other. Consequently two points on the same conductor may be momentarily at very different potentials. In the second place the amount of energy stored in the electrostatic capacity of the commercial circuit is very much larger than that in the "conductors" of laboratory experiments. It should be noted that these points of differences are both differences of degree, not of kind.

It will be well at the outset to summarize briefly the most characteristic of the laws of static. These are all well known and of very general applicability, viz.:

LAWS OF STATIC.

I. A static discharge (which is merely a very sudden rush of electricity) encountering a choke coil in its path, experiences momentarily great opposition, *i. e.*, the electricity is temporarily held back by the inductance of the coil so that if the rush of electricity be of large volume and sufficiently sudden a very great electromotive force (neglecting losses of energy) will be exerted on the choke coil. This high electromotive force is but momentary, however, as the choke coil after the first instant allows the electricity to pass at an accelerating rate which soon relieves the pressure. The high momentary pressure at the front of the choke coil causes a tendency for the charge to seek other paths. Such a phenomenon would be called "side flash," and is one of the considerations which led to the use of choke coils with lightning arresters. Lightning arrester choke coils are so placed that any static disturbance on the line must pass the choke coil to reach the apparatus which is being protected, and the arresters are placed on the line side of the choke coils where the tendency to side flash is strongest.

As there is a tendency to side flash toward other objects there must evidently also be a tendency to short circuit the choke coil itself. Such short circuits are by no means unusual when coils not designed to withstand them are exposed to static discharge.

III. All conducting bodies have electrostatic capacity, or, in other words, are to a greater or less degree condensers. Whenever a conductor is at a potential different from a neighboring conductor a charge of electricity appears in its surface principally on the side toward the other body. The amount of this charge equals the product of the electrostatic capacity and the potential between the bodies. At the same time an exactly equal charge appears on the second body. A conductor may have capacity to two or more adjacent conductors at the same time; in this case its resultant charge is the sum of the separate charges.

The fact that a certain quantity of electricity, great or small, is required to charge any conductor to any definite potential is very important in its bearing on long distance lines. Suppose, for instance, that a piece of apparatus at one end of a transmission line is to be raised to a certain potential by a sudden application of voltage at the other end. A sensible time will elapse before the necessary charge for the apparatus can reach the end of the long line. Consequently the potential of the apparatus will not raise at the same instant as an applied electromotive force, but will remain unchanged until charge actually reaches it. In other words, the potential of a condenser cannot rise until the charge necessary to produce this rise has entered it.

The large current required to charge the line wires of an extensive high tension system is well known. All switches, transformers, instruments and other apparatus actually connected to the high tension circuit also require charge, though of course much less.

The line wires have electrostatic capacity both to the earth and to one another. The several charges corresponding to those different capacities though superposed on the wave, act independently of one another and must be so studied. Similarly with apparatus connected to the lines, not only will there be electrostatic capacity in the high tension parts to ground and low tension parts, but also between different parts of the high tension windings themselves.

III. When a current is flowing through a circuit containing inductance, energy is stored in its magnetic field. The amount of this energy equals one-half the product of the inductance and the square of the current. This energy was obtained from the circuit when the current was started and when the electromotive force producing the current is removed, this stored energy must be discharged back into the circuit before the current can stop. If the circuit be suddenly opened a very high potential will be developed to keep the current flowing until this energy is fully discharged. Such is the case of the well known rise of potential which results from suddenly opening the field circuit of a large generator. The direction of this "extra" electromotive force, when the circuit is opened, is always such as to continue the current flow.

Energy in a magnetic field is just as truly stored energy as that in the moving bullet, the stretched spring, or the raised weight. It may be adapted to useful purposes. For example, the energy stored in the magnetism in the core of an induction coil by the primary current is discharged into the secondary to produce the high tension spark. An idea of the amount of this energy in actual cases may be obtained from the following:

One ampere flowing through a coil w with an inductance of one henry (equivalent to 377 ohms at 7200 alternations) stores one-half volt-ampere seconds equal one-half watt-second, equal one-half joule equal 0.367 foot-pounds.

The very sudden rushes of static electricity are no exception to this law; they produce magnetism and store energy which must be discharged into the circuit again before the currents can cease. This principle will be found to lead to important results.

Also, when a condenser is charged energy is stored. This energy will be restored to the circuit again when the condenser is discharged. The amount of this energy is one-half the product of its electrostatic capacity and the square of the voltage. A condenser of one microfarad capacity charged to 1000 volts potential stores one-half a watt-second equal one-half joule, equal 0.367 foot-pounds.*

*The transmission lines of a system like the Bay Counties Power Company of California, with lines 150 miles long, have a capacity of about three microfarads. Operating at 40,000 volts this will have $\frac{1}{2}\times(3\times10^{-6})\ (40{,}000\times\sqrt{2})^2 =$ 4800 watt-seconds, $=$4800 joules, $=$3500 foot-pounds of energy stored in its electrostatic capacity when fully charged. The charging current is 45 amperes at 40,000 volts, 7200 alternations. Therefore the rate of supply of energy to the line from the generator and absorption from the line to the generator is $45\times 40{,}000\times 2\times\frac{1}{\pi} = 1{,}150{,}000$ watt-seconds per second, $=1{,}150{,}000$ joules per second, $=843{,}000$ foot-pounds per second. The generator supplies current continuously to the line for one-half an alternation and then receives it back again for the next half alternation. Therefore the energy delivered or received in a half alternation is the energy stored in the capacity of the line $=\frac{45\ s\times 40{,}000\times 2}{\pi\times 60\times 4} =$ 4800 watt-seconds, $=$4800 joules, $=$3500 foot-pounds, as before.—P. H. T.

The energy of an electric current may thus be stored in two ways, either in a magnetic field produced by a current, or by the storing of the electricity itself. In its former state the energy may be regarded as kinetic and in the latter as potential.

It has been stated that an electric circuit may be considered as an insulated conductor of a peculiar form. It is rather an aggregation of conductors of various forms. In general a high tension circuit consists of the following parts: (*a*) High tension windings or transformers, raising and lowering. (*b*) Transmission wires. (*c*) High tension switches, instruments, lightning arresters, station wiring and similar auxiliary apparatus.

ELECTRIC CIRCUIT AS AN INSULATED CONDUCTOR.

(*a*) The high tension transformer windings are in the form of coils, and are, therefore, from the static point of view, choke coils. On account of the very large number of turns their choking power is very great (choking is general, being proportional to the square of the number of turns). The high tension windings have electrostatic capacity also as they lie close to the low tension windings and to the core, that is, the high tension winding will have static charges on the surface opposite the low tension winding and opposite the core. There is, as well, capacity between turns and between coils of the high tension windings. The electrostatic capacity of these transformer coils is of a rather complicated nature, for it is distributed along at different points on the winding, and is not concentrated at one point as in an ordinary condenser. Therefore, the charge for the different portions of the windings must pass through different lengths of wire and different amounts of inductance and resistance. The same is true of both raising and lowering transformers.

(*b*) The transmission wires have electrostatic capacity with one another and with the earth, so there are two charges superposed on each wire, each of which may act independently of the others. This capacity, though comparatively small for short lengths of wire, is, as a whole, great on account of the great length of the lines. These wires have inductance also like the capacity; small for short lengths, but quite considerable when the line is taken as a whole.

On the line wires, as in the high tension transformer windings, the electrostatic capacity and inductance are distributed, so that when voltage is applied to the line different points receive charging current at different instants of time, since the charge for various points must flow through different lengths of line. In fact, the transmission wires (the same may be said of high tension transformer winding) may be considered as a succession of choke coils and condensers in series, each very small, but very great in number, as shown in Figure 1.

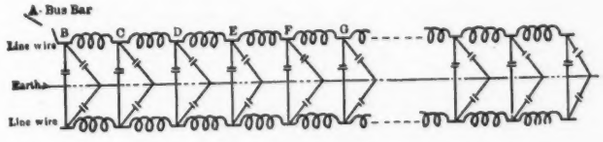


FIGURE 1.—ILLUSTRATING INDUCTANCE AND CAPACITY OF A LONG SINGLE PHASE TRANSMISSION LINE.

In addition to the electrostatic capacity of the line wires there is a certain amount of capacity on each insulator. The amount is very small, and may be considered a part of the line capacity.

(*c*) Switches, instruments, lightning arresters, station wiring and similar auxiliary apparatus have a certain amount of electrostatic capacity to surrounding objects, but not usually as much as the high tension windings of transformers. This part of the system has also comparatively little inductance and needs no further discussion here.

In addition to electrostatic capacity and inductance all parts of the high tension system have more or less ohmic resistance. The effect of this resistance is to retard the current (static or normal) in whatever direction it flows, and to change part of the electric energy into heat.

A certain amount of current leaks from the line at insulators and at all points where insulating material touches the circuit, since no insulation is perfect. Even the air conducts away some charge when the voltage is extremely high. Taken altogether the result of these leakages is small under normal conditions and may be neglected in this discussion.

Every point of a high tension circuit at any instant has a perfectly definite potential, which is in general different from the potential of other parts of the circuit and of adjacent objects. Consequently each point has at each instant a definite static charge, often different from that of other points. As (with alternating currents) the potential of each point is varying from instant to instant, these charges are continually changing, and the changing charges cause a current in the circuit properly called charging current. Neither this charging current nor the static charges have any connection with the useful current except as the latter may influence the static potential of some point of the circuit. The total current in the circuit at any instant is the sum of the work current and charging current if they are in the same direction, or their difference if they are in opposite directions.

When the potentials of all points of a circuit are determined directly by the electromotive force of the generator, *i. e.*, during normal operation, all changes of potential are slow (compared with static changes of voltage) and allow sufficient time for the necessary changes in the static charges at various points to be accomplished without serious opposition from the inductance of the circuit. Such changes of potential and charges as these, however, are not the subject of this paper. Its principal object is the discussion of changes of potential of a more abrupt nature, which are not directly produced by the electromotive force of the generator; the latter may cause violent and sudden alterations of the static charges and dangerous local potential strains. However, before taking up the more complicated case of the abrupt changes, it will be best to consider a little more fully the distribution of potential and charge in some of the simpler cases of normal running, viz.:

Static Charges on a Symmetrical Single-phase Transmission Line Open Circuited at the End and Charged by a Direct Current Generator.—In this case both lines have the same electrostatic capacity to the earth. There is also capacity between the line wires. On the positive line is a positive charge composed of two parts, one due to its capacity to earth and the other to its capacity to the other wire; similarly on the negative wire is an equal negative charge composed of two parts. These charges remain constant as long as the electromotive force of the generator is constant.

If, however, the generator is an alternator the charges change from positive to negative with the voltage remaining equal on the two wires at all times. This interchange of charges requires a flow of current from line to line through the generator.

When the same line is loaded at the farther end no material change is produced in the line charges. Since different parts of the high tension winding of the motor or transformer or other apparatus constituting the load are at potentials varying all the way from one-half line voltage positive to one-half line voltage negative, the charges on these points will vary in a similar manner. These charges are supplied from the generator through the line. The charges for the inner parts of the winding of the load apparatus must flow through the outer parts of the winding as well as through the line.

Same Line With One Leg Grounded.—Since direct current is practically never used in high tension work it will be omitted from further discussion here. The case of a grounded line is of importance not as a practical operating condition, but on account of the harmful results which may follow accidental grounds. The potential of one line wire becomes the same as that of the earth while that of the other is full line voltage, that is, double its value with circuit ungrounded. The potential between the wires being maintained by the generator remains unchanged. Of the two component parts constituting the charge on the underground wire the

part due to the electrostatic capacity between the wires is undisturbed by the grounding since the voltage between wires is unchanged, but the part due to the capacity to earth is doubled since the potential of the line above the earth is doubled. On the grounded line the part of the charge due to the electrostatic capacity between wires is unchanged—the part of charge due to capacity to earth becomes zero, since the potential to earth is zero. The charge which appears on the earth opposite the underground wire and which is equal in amount to the part of that line's charge that is due to capacity with the earth, being produced by the generator, must flow to earth at the point where the circuit is grounded. On a large system the electrostatic capacity of the lines would be sufficient to make this current quite large. In such a case the current may burn off the line wire at the grounded point if the contact with the earth is imperfect. This fact has a very direct bearing on the question as to whether it is possible to operate a large high tension system with one wire accidentally grounded.

System With Neutral Point Grounded.—In a symetrically arranged ungrounded system, either single phase or polyphase, a neutral point may be defined as any point which is at the earth's potential. There may be more than one neutral point in a circuit, as shown in Figure 2, where *a*, *b*, *c*, *d* are neutral points.

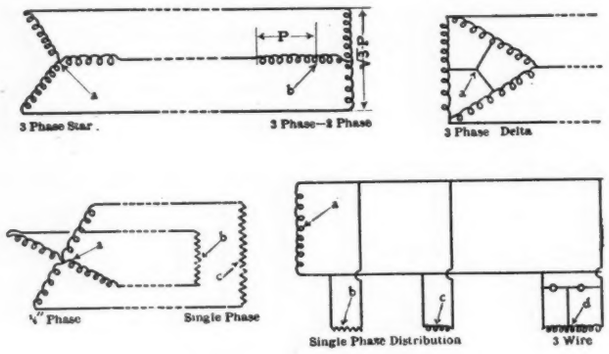


FIGURE 2.—NEUTRAL POINTS.

Since the neutral point is at the earth's potential, grounding this point makes no difference in the potential or charge of any point of the circuit, and no current flows over the grounding wire. If the circuit becomes unbalanced, for example, by a high resistance ground on one wire, there is a tendency for the neutral point to take a potential different from that of the earth and a current will then flow over the grounding wire which will be sufficient to keep the neutral point at earth's potential. If there be a dead ground on one wire the earth connection at the neutral point completes a short circuit. If the neutral point is not grounded when the system becomes unbalanced one or more lines will take a potential higher above the earth than in the balanced condition and the other line or lines a potential lower than before. Therefore, comparing the two methods of operation with the neutral grounded, if a "dead" ground is made on any line wire a short circuit is produced through the ground connection at the neutral point; with the neutral undergrounde d a ground on a line wire means twice the previous potential between line and ground on one or more wires though no short circuit is produced. The advantage of a grounded neutrel is the preventing of increased potential over the earth in case of an accidental ground, its disadvantage is the fact that one such accidental ground instead of two causes a short circuit.

We may now consider some of the abrupt changes of potential not directly produced by the generator.

(Continuation in the ensuing number.)

LATE CROCKER-WHEELER INSTALLATIONS.

The Crocker-Wheeler Company of Ampere, N. J., has just issued a new bulletin, No. 18, describing the electrical equipment of the Joseph Dixon Crucible Company of Jersey City. This company, which formerly operated four separate steam plants, has now combined them into one electric power plant. A 100-kilowatt generator and twenty-four motors, all of Crocker-Wheeler manufacture, have already been installed, and future equipment is contemplated.

The company reports that the outlook at the end of the first month of the new year is most promising, both in present orders coming in and in the indications for a heavy spring business. Among the January shipments may be noted the following:

De Lamar Copper Refining Company, Carteret, N. J., one 520-kilowatt generator, 1 100-kilowatt generator, one 50-kilowatt generator. Iron City Engineering Company, Uniontown, Pa., four 100-kilowatt generators. Anglo-American Provision Company, Chicago, Ill., seven motors ranging from ten to seventy-five horsepower. Pennsylvania Steel Casting Company, Chester, Pa., one 350-kilowatt generator. Quintard Iron Works, New York City, one sixty-five-kilowatt generator. Marine Engineering and Machine Company, Harrison, N. J., two, size 111, fifty-kilowatt generators, one sixty-horsepower motor, two thirty-five-horsepower motors. United States Electric Lighting Company, Washington, D. C., one ninety-kilowatt generator, one 130-horsepower motor. National Tube Company, Pittsburg, Pa., a consignment of motors. Erie Rapid Transit Railway, Harbor Creek, Pa., one 200-kilowatt generator. L. S. & M. S. Railway shops, Collinwood, Ohio, one 400-kilowatt generator, one seventy-five kilowatt generator. Mechanical Laboratory, Lehigh University, South Bethlehem, Pa., one thirty-kilowatt generator. American Car and Foundry Company, Madison, Ill., one 110-kilowatt generator. Armour Fertilizer Works, Atlanta, Ga., one 150-kilowatt generator, two fifty-horsepower motors, one ninety-horsepower motor. Park Steel Company, Pittsburg, Pa., one 200-kilowatt generator. J. K. Farley Manufacturing Company, Chicago, Ill., one 150-kilowatt generator. Fort Hill Chemical Company, Rumford Falls, Me., four 140-kilowatt generators.

EMERSON FAN MOTORS.

The California Electrical Works, 547 Mission Street, San Francisco, is distributing a particularly attractive catalogue illustrating the line of Emerson Alternating Desk and Fan Motors, for which they are agents. This catalogue is one of the most artistic ones published for the fan motor season, 1902. The fans described in this catalogue embody to the highest degree the desirable qualities of extreme durability, economical current consumption and pleasing design. A large stock carried in San Francisco.

LOS ANGELES OFFICE OF THE S. K. C. SYSTEM.

Messrs. Jno. Martin & Co., Pacific Coast Representatives of the Stanley Electric Manufacturing Company, of Pittsfield, Mass., have opened an office in the Douglas Building, Third and Spring Streets, Los Angeles. The Jno. Martin & Co. already have offices at San Francisco and Seattle, Wash.

TRANSMISSION IN AGRICULTURAL DISTRICTS.

Water power from the Bode River, supp'emented by a steam plant, is utilized at Crottorf, in Germany, to the extent of 1750 horsepower, through a 7000-volt, eighteen-mile, three-phase transmission for lighting and power purposes, the main use of power being especially for threshing grain. High tension current is taken from pole lines in the open fields and delivered to portable trrnsformers located on a wagon, and the motor for driving the thresher is similarly mounted, so as to be portable and easily connected to the thresher. An English contemporary* makes brief reference to the installation, which would seem to be worthy of more extended notice.

**The Electrical Engineer*, (London), Volume XIX, page 183, February 7, 1902.

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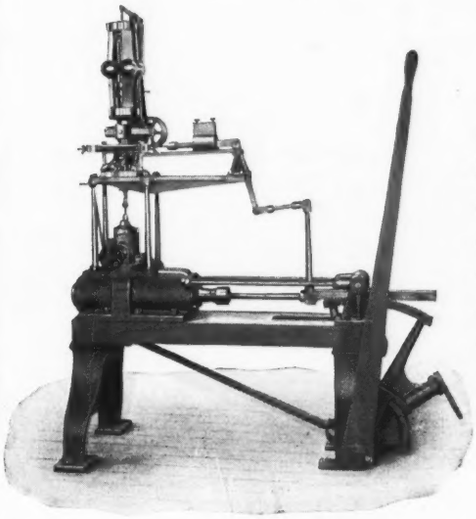

Those who have received our 1902 catalogue may have noted on page 62 a voltage chart and load chart attributed to the Edison Electric Company of Los Angeles. This was an error *on our part*, as the charts in question show the load and voltage lines in the plant of the San Gabriel Electric Company of Los Angeles. Both of the above named companies use our governors, and letters from them both appear in our catalogue, which is very interesting reading to those who are investigating the speed regulation of water wheels. Write for a copy. We guarantee our governors to give the best attainable speed regulation.

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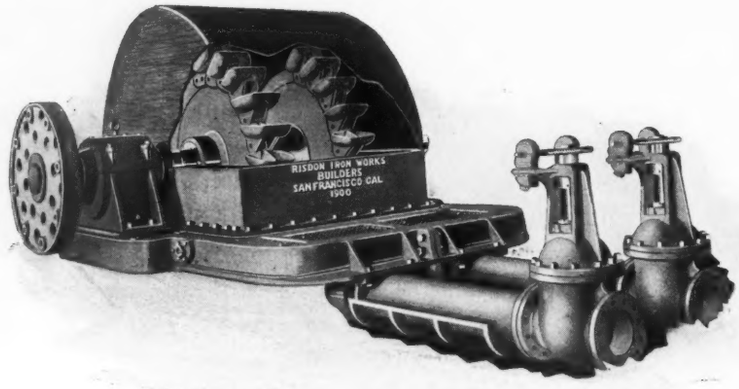

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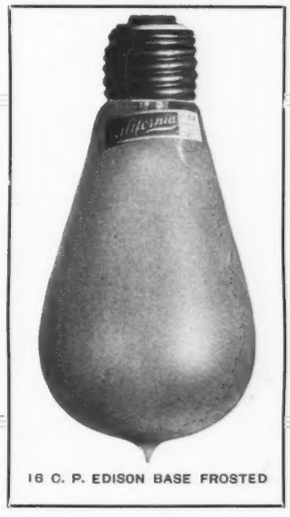

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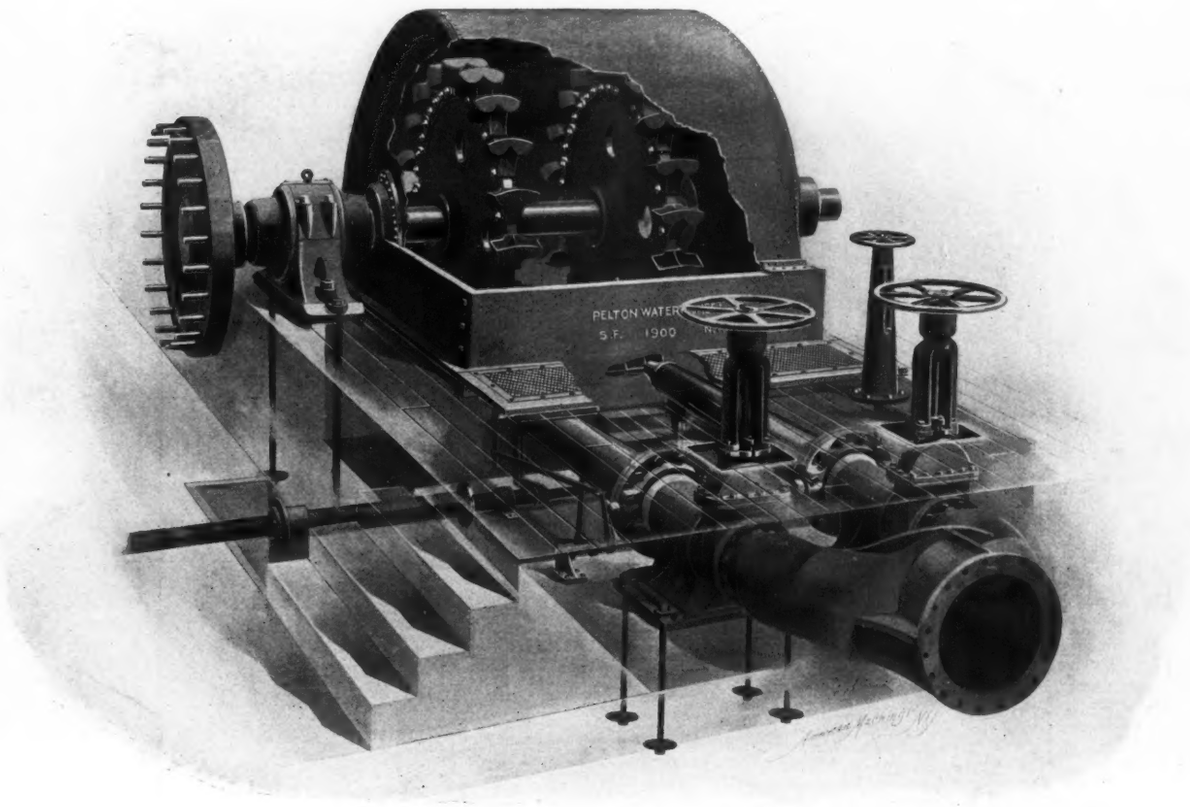

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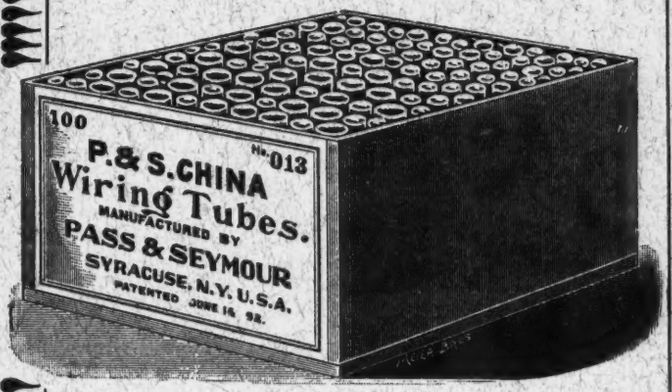

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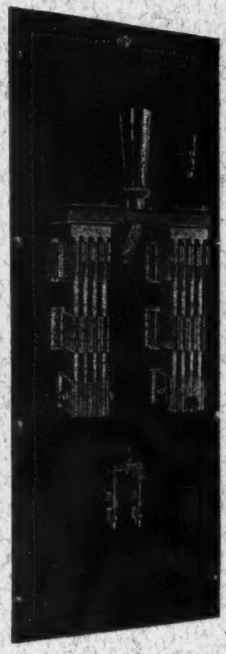

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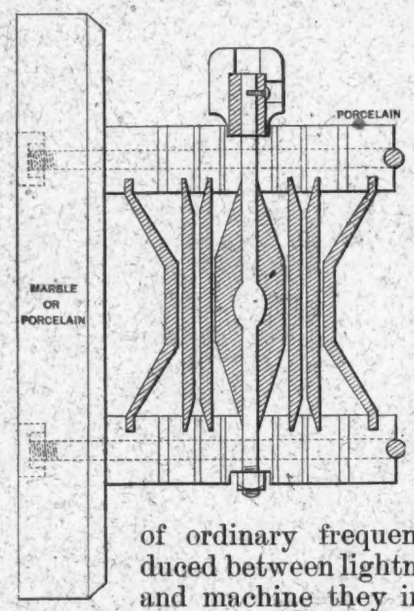

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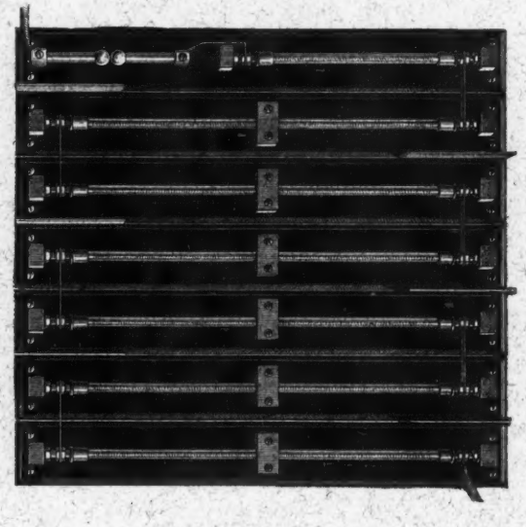

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